U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN No. 26.

RECORD OF EXPERIMENTS

IN THE

PRODUCTION OF SUGAR FROM SORGHUM

IN

1889

AT CEDAR FALLS, IOWA; RIO GRANDE, NEW JERSEY; MORRISVILLE, VIRGINIA; KENNER, LOUISIANA; COLLEGE STATION, MARYLAND; AND CONWAY SPRINGS, ATTICA, MEDICINE LODGE, NESS CITY, LIBERAL, ARKALON, MEADE, MINNEOLA, AND STERLING, KANSAS.

BY

H. W. WILEY,

CHEMIST.

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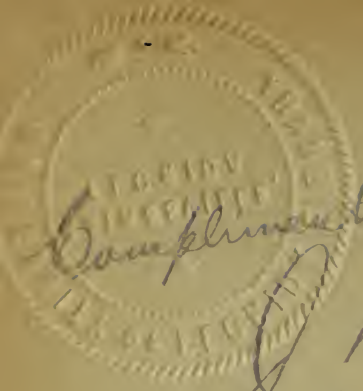

Compliments of

J. M. Rusk

Secretary of Agriculture

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PREFATORY NOTE.

SIR: I have the honor to submit herewith, for your approval and inspection, a report on the experiments conducted under my direction during the past year relating to the manufacture of sugar from sorghum.

Respectfully,

H. W. WILEY,
Chemist.

Hon. J. M. RUSK,
Secretary.

RECORD OF EXPERIMENTS IN THE MANUFACTURE OF SUGAR FROM SORGHUM IN 1889.

The experiments in the manufacture of sugar from sorghum conducted by the Chemical Division of the Department of Agriculture during the season of 1889 were divided into two classes, viz:

(1) Culture experiments; having for their object the improvement of the cane in respect of its sugar-producing qualities.

(2) Chemical control of the manufacture of sugar from the cane; having for its object the demonstration of the sugar-producing power of the cane entering into manufacture and the location of sources of loss.

In some cases the two classes of experiments were combined, as at Kenner, Rio Grande, and Attica; in others they were entirely separated, as at the Maryland stations and at Sterling. From the totally different character of manufacturing and culture experiments it is easily apparent that only the best results can be obtained in each case when the two kinds of work are kept entirely separate.

During the manufacturing season both proprietors and chemists must of necessity be primarily interested in saving the crop. In the face of this necessity the purely cultural part of the work must suffer. This same remark may be applied but with less force to the growing season. The important work at this time is to produce a crop ready for the mill, and but little thought and attention can be given to problems of producing new varieties and improving old ones. The experience of the last two seasons has furnished proof of the truth of the above theoretical conclusions. Only at those stations where no manufacturing operations have been carried on have the most valuable results been obtained in culture work, while at manufacturing stations the work of the chemical control of the factory has been made of paramount importance.

CHARACTER AND ALLOTMENT OF WORK.

On March 2, 1889, the bill appropriating the unexpended balance of last season's sugar fund, $59,984.77, and granting an additional sum of $25,000, became a law.

The change of administration which was to take place on the 4th of March induced the retiring Secretary of Agriculture to postpone all arrangements for work in this matter for his successor. The delays in-

cident to the induction of the present Secretary into office prevented any arrangements being consummated for the work until April 4, 1889. At that time I was authorized by the Secretary to make arrangements for certain culture experiments, and on May 4, 1889, I was directed by him to visit some of the places where it was proposed to conduct experiments and make a study of the conditions presented. On May 6, 1889, Mr. W. W. Cook, of Medicine Lodge, Kans., was commissioned by the Secretary as an agent of the Department to act subject to my instructions.

In May I proceeded under authority above mentioned to Kansas and Iowa and visited the stations at Attica, Conway Springs, Medicine Lodge, Sterling, and Cedar Falls. At the same time I directed Mr. Cook to visit other stations where sugar factories were building.

Information respecting proposed operations at Rio Grande, Morrisville, and Kenner was also obtained, and the results of all this work were collated in a report submitted to the Secretary on June 1, 1889.

The general conclusions reached by a study of the data obtained were as follows:

GENERAL CONCLUSIONS.

"I have endeavored to lay before you in the preceding report as many of the details of the present condition of affairs in the sugar region as are necessary for a proper understanding of the present conditions of the problem. It appears to me that the most favorable conditions for success in the manufacture of sugar from sorghum are found at the three stations of Conway Springs, Attica, and Medicine Lodge. Of these three the station at Attica is the most advanced; while the station at Medicine Lodge is the only one which, in my opinion, has a sufficient water supply. In case no delay is experienced by the company at Medicine Lodge in the erection of the machinery I shall expect to see the best results of the season's work at that place, Attica coming second, and Conway Springs third, according to present appearances.

I find all the people engaged in the business are underestimating the difficulties to be encountered and overestimating the appliances at hand. Some of the men engaged this year in the work have had many years' experience and yet they seem to be still oblivious to the most patent facts which have been developed especially by the experiments of the Department. The trouble seems to arise from a failure to investigate the matter from a non-partisan basis. One of the great difficulties in all the sorghum sugar ventures has been a lack of capital. In order to secure a sufficient investment of funds, I fear it has often been the custom to ignore the difficulties of the problem and to present only to the intending investor the rosy side of the question. It would appear, after the publication of Bulletin No. 20, in which the great danger of undertaking work in the manufacture of sorghum sugar without a sufficient water supply was fully pointed out, that one of the first things to be looked after by the intending builders would be a supply of water sufficiently abundant for all possible emergencies. Instead of having

done this we find that in Kansas only one factory has been placed where the water supply is practically inexhaustible.

The chemical force at my disposition was assigned as follows:

To Cedar Falls, A. E. Knorr; Rio Grande, H. E. L. Horton, assisted by G. E. Rockwood; Morrisville, W. Maxwell; Conway Springs, E. A. Von Schweinitz, assisted by Mr. Meechem and J. G. Hoffman; Attica, Oma Carr, assisted by Lewis H. Bradford; Medicine Lodge, Hubert Edson, assisted by T. F. Sanborn; Ness City, K. P. McElroy, assisted by S. B. Merrill; Liberal, Arkalon, and Meade, J. L. Fuelling, assisted by Erwin E. Ewell; Sterling, C. A. Crampton, assisted by M. B. Clement.

Only one chemical outfit was provided for the three stations at Meade, Arkalon, and Liberal, because these three stations were under the same control near together and similarly situated in respect of soil and climate. Moreover it was found impracticable to equip and use an additional number of laboratories.

It may not be complimentary to the agricultural chemical education given in our schools, but nevertheless it is true that it was impossible at the time to secure additional chemists competent to exercise the control desired. Inasmuch as the necessary technical knowledge for such work is easily attained, it is to be hoped that another season will see a number of agricultural chemists prepared for such work sufficiently large to satisfy all demands. In view of the rapid increase in the number of sugar factories requiring chemical help it might be well to consider the propriety of establishing a special school in which instructions could be given in the theory of sugar production and manufacture, the school being transferred to the sugar belt during the manufacturing season for practical instruction. Graduates of agricultural colleges who have paid proper attention to chemistry should be able in one year under proper instruction, as outlined above, to take charge of chemical work in a sugar factory.

Since the establishment of an indigenous sugar industry is a matter of the greatest national importance, it would seem proper for Congress to take the initiative in the establishment of a national sugar school.

In addition to the work done by the stations named the chemical work of the College Station culture experiments was done in this laboratory by Messrs. Trescott and Dugan. The samples of cane were sent in each morning by express, reaching the laboratory by 9 o'clock.

The following brief statement of the equipment of the several factories in Kansas was prepared by Mr. G. L. Spencer:

THE SOUTHERN KANSAS SUGAR COMPANY, CONWAY SPRINGS, KANS.

Estimated capacity.—The capacity of the works is estimated at 200 tons of clean cane per twenty-four hours.

Steam.—The steam is supplied by four multitubular boilers of 150 horse-power each.

Cane-racks.—The cane is unloaded directly from the farmers' wagons upon long

racks, whence it is drawn by machinery to the carriers. These racks have storage capacity for sufficient cane for the night's work.

Cutters.—The preparatory cutter consists of two circular disks of iron fitted with a shaft, etc., and carrying two heavy knives. The knives are bolted to the opposite parts of the circumference of the disks in such a manner that when the cutter is in revolution their edges describe a cylinder. They are set parallel to the shaft. A third disk of lighter weight supports the knives at the central point and prevents their springing.

The following are the dimensions of this cutter: Diameter, 30 inches; length of knives, 3 feet in the clear; diameter of shaft, 4 inches; thickness of the disks at the rims, 4 inches; driving pulley, 14 inches diameter by 8 inches face. The speed of the cutter is approximately 230 revolutions per minute.

The carrier ends about 3 feet from the cutter and a few inches higher than the dead-knife, delivering the cane upon an inclined chute. Two rollers forming a forced feed carry the cane to the knives. The cane leaves are separated from the cuttings by a series of fans.

The shredders.—The shredders, two in number, are of the Hughes system. Their dimensions are as follows: Length of cylinder, 24 inches; diameter, 8 inches; shaft, 2¼ inches diameter; driving-pulley, 12 inches diameter by 6 inches face. Each cylinder carries four knives.

The cutters and shredders were built by the Kilby Manufacturing Company.

Diffusion batteries.—The works are provided with two diffusion batteries, one of which was constructed and operated in 1888. This battery has a net cane capacity of 50 cubic feet per cell. The upper and lower doors are the full diameter of the cell. Solid rubber gaskets are used for the lower doors instead of the hydraulic closure. It is significant that the battery of the Attica Company by the same designer is provided with the hydraulic closure. The juice and water mains are 3 inches in diameter. These mains are too small for rapid work. The heating surface of the calorisators is also insufficient. A comparison of the analytical work of this battery and the new one about to be described will be of value in determining the influence of the form of the cell as affecting the extraction and dilution.

The cells of the second battery, constructed by the Kilby Manufacturing Company, are similar in form to those atMagnolia plantation (see Bulletin 21), differing only in having a slightly larger diameter at the discharge door than at the shoulder.

The object of this increase in the diameter is to facilitate the discharge of the exhausted chips. The lower doors are operated from the upper platform by an hydraulic attachment. The net capacity of each cell is 65 cubic feet of chips. The juice and water mains are 4 inches in diameter. This battery seems well proportioned for rapid and effective work.

The batteries have twelve cells each and are arranged in single lines, parallel with one another. One set of men operates both batteries.

Exhausted Chips.—The exhausted chips are dumped into carts and hauled to the fields.

Clarification.—A continuous clarifier (see page 8, Bulletin 17), similar to that employed at Fort Scott in 1887, was the only means of clarification in use the first part of the season. This apparatus was insufficient both as regards capacity and efficiency. It is the intention (September 7, 1889) to increase the clarifier capacity by the addition of several of the ordinary form of clarifiers.

Evaporation.—The juice from the clarifiers, after settling in tanks, is concentrated in a 15-coil Yaryan double-effect.

Granulation.—The sirups are boiled to grain in a vacuum pan of the ordinary form.

Centrifugals.—Six Hepworth centrifugals are employed in purging the sugars.

Water supply.—The water supply is drawn partly from a creek and partly from a large well used last season. The water from this latter is strongly impregnated with gypsum. The pipe line from the creek is of insufficient capacity.

THE MEDICINE LODGE SUGAR WORKS, ELDRED & HINMAN, PROPRIETORS, MEDICINE LODGE, KANS.

Estimated capacity.—Capacity 200 tons of clean cane per twenty-four hours. The machinery is probably of a capacity considerably greater than the guaranty.

Buildings.—The main building is 148 feet by 48 feet, the boiler house 50 feet by 90 feet, the laboratory and office 60 by 20 feet.

Location of machinery.—The water pumps and the receiving tank for the condensation are in the boiler-house.

The central portion of the main building rises about 40 feet above the main roof and contains the pressure tank and the water supply for the Yaryan and the strike-pan.

All the pumps, engines, etc., are on the ground floor. The battery extends in a single line parallel with the length of the building. The cutters, shredders, and pans are on the opposite side of the building near the battery.

The Yaryan double-effect and the vacuum pan are on the second floor opposite the battery.

The centrifugals are in the east end of the building conveniently located in regard to the vacuum pan and the hot room.

Steam.—The steam supply is obtained from six 125 horse-power multitubular boilers.

Cane-racks.—The racks for the storage of cane have an estimated capacity of 150 tons.

Cutters and shredders.—The cutters and shredders are from the same patterns as those at Conway Springs. The leaves are separated as usual by means of fans, and are then carried outside the building by a Sturtevant exhaust-fan.

Diffusion battery.—The cells of the battery are larger in diameter at the bottom than at the top, the average being 50 inches. They have a net cane capacity of 105 cubic feet.

The shredded cane is distributed to the battery, which is arranged in a single line, by means of an endless belt. The battery is composed of twelve cells and differs from that at Conway Springs only in being of larger dimensions.

Exhausted chips.—The exhausted chips were to be carried 100 yards or more distant from the building in a cable car provided with an automatic dumping arrangement, but owing to the failure of this car the chips were flushed into a creek by the waste water from the multiple-effect and strike-pan.

Clarification.—The ordinary method of clarification as used in Louisiana is employed.

Evaporation and granulation.—A 15-coil Yaryan double-effect is employed for the concentration of the juice, and a vacuum pan, 8½ feet diameter, for the granulation of the sugars.

Centrifugals.—The centrifugal equipment consists of five machines, Hepworth's latest improved.

The water supply.—The water is derived from Elm Creek. This is the only sugar-house visited by the agent of the Department whose owners seemed to realize the fact that a sugar-house requires an immense volume of water. The water pumps are very powerful and the supply of water ample.

The house was built and equipped by the Kilby Manufacturing Company.

THE ATTICA SUGAR COMPANY, ATTICA, KANS.

Estimated capacity.—The estimated capacity of these works is 200 tons per twenty-four hours.

Steam.—Two Hazleton tripod boilers, one of 400 horse-power, and the second of 300 horse-power furnished ample steam for the sugar-house. A Rooney automatic stoker is attached to one boiler.

Cane-racks.—The cane racks have storage capacity for 120 tons. They are so arranged that the cane can be delivered to the carrier in bunches. This facilitates the removal of the seed heads.

Cutters and shredders.—The cutters (two) do not differ materially from those at Conway Springs and Medicine Lodge, which are described elsewhere in this report. The carriers end abruptly a few inches from the cutters, leaving a space for the panicles, which are too heavy to be drawn in, to fall on a drag below. The shredders are also similar to those at Conway Springs and Medicine Lodge. They are two in number, each cylinder 24 inches long and 8 inches diameter.

Diffusion battery.—The diffusion battery single line arrangement consists of 12 cells each of 105 cubic feet capacity. The cells are provided with the hydraulic closure. The cane chips are automatically treated with powdered slacked lime before passing into the cells.

Exhausted chips.—The exhausted chips are passed through a five-roll mill preparatory to burning under the boilers. Owing to the weakness of the mills the extraction is poor, and consequently the chips are in a poor condition for use as fuel. Notwithstanding these difficulties this sugar-house burns a portion of its chips.

Clarification.—A continuous clarifier (see page 8 Bulletin 17) is employed in the purification of the juice.

Filtration.—The juice from the clarifier is filtered through ordinary presses. Before entering the filter-press it is treated with live steam, the steam also furnishing the pressure for filtration.

Evaporation.—A double-effect of the ordinary system (1,000 square feet heating surface per pan) is employed for the concentration of the juices.

Extra bottoms are provided for these pans, for use in salt manufacture. Also for this reason the pans are very high in proportion to their diameter.

Granulation.—The sirups are boiled to grain in vacuum pans of the ordinary form. This house is provided with two such pans.

Centrifugals.—The centrifugals, five in number, are of the Hepworth make (West Point foundry).

Water supply.—The supply of water is derived from a small creek, and is hardly sufficient for the needs of the house.

THE SOUTHWESTERN SUGAR COMPANY.—WORKS LOCATED AT MEADE, ARKALON, AND LIBERAL, KANS.

These three houses, built by one manufacturer, differ but little in arrangement and are of equal capacity, hence a description of one will answer for the three.

Estimated capacity.—The rated capacity of each house is 150 net tons per twenty-four hours.

Steam.—The steam is supplied by six multitubular boilers of approximately 75 horse-power each.

Cane platform.—The method of handling the cane is very simple and deserves especial mention. The carrier extends the entire length of the center of a broad platform; the sides of the carrier form a guide and support for a movable frame to which a block and fall are attached. When a load of cane is to be discharged, the wagon is backed up to the platform, the frame is moved to a part of the carrier opposite, and the fall is attached by means of two hooks to the ropes binding the cane; the free end of the fall is passed around a capstan driven by power. By means of this arrangement the cane is easily drawn off the wagon upon the platform convenient to the carrier. In case of difficulty in backing a wagon up to the platform, the fall can be attached and power be applied to bring it to the proper position. The platform has capacity for the storage of sufficient cane for the night work.

Cutters.—The preparatory or ensilage cutter is built upon an entirely different principle from those in use at other sorghum sugar houses. It consists essentially of two cranks similar to those of a locomotive, connected by a heavy knife; this lat-

ter replacing the parallel or side rod of the locomotive. It may be seen that the revolution of the crank-shaft communicates a drawing motion to the knife. An ordinary carrier delivers the cane to suitable feed-rolls, which in turn carry it forward upon a corrugated dead-knife, which latter prevents slipping when the knife descends to make the cut. The peculiar arrangement of this cutter enables it to make a smooth draw cut, without splitting the cane. This insures a more thorough removal of the leaves and trash by the fans. The seed heads fall through an opening between the feed-rolls and the cutter upon an auxiliary carrier, as in the Hughes system.

The dimensions of this cutter are as follows: Knife blade, one-eighth inch thick, 6 inches broad, and 50 inches long; two balance wheels 28 inches in diameter each; driving pulley, 24 inches in diameter, 8 inch face.

The shredders.—The shredders are of the Hughes system, so arranged that one can be employed while the knives of the second are being reset. These machines do not differ materially from those in use in the factories already described in this report. Dimensions: Diameter of cylinder, 8 inches; length, 24 inches; shaft, 2¼ inches diameter; driving pulley, 12 inches diameter, 6 inch face. Each cylinder carries six knives.

Diffusion battery.—The battery is arranged in a single line of fourteen cells. Each cell has a net cubical capacity of 60 feet. The lower doors are of the full diameter of the cells and are operated by block and fall. The hydraulic closure is employed for these doors. The juice and water mains are 3½ inches in diameter.

Exhausted chips.—The exhausted chips fall into a cable car and are carried outside the building.

Clarification.—The ordinary method of clarification is employed.

Evaporation.—The juices are concentrated in a Swenson triple-effect apparatus.

Granulation.—The sugars are grained as usual in a vacuum pan.

Centrifugals.—The centrifugal equipment consists of three machines, Hepworth's latest improved.

On September 14 I was ordered to report to the Secretary in Chicago and accompany him on a tour of inspection in Kansas. The factories at Minneola, Meade, Arkalon, Liberal, Attica, Medicine Lodge, Conway Springs, and Fort Scott were visited during the latter part of September. The condition of affairs in most of the places visited was discouraging. At Minneola, Meade, Arkalon, and Liberal the drought had cut the cane crop short and the greater number of the fields of cane presented plants dwarfed, immature, and shriveled, thoroughly unfit for sugar making. Of the four factories first named, only one, viz, at Liberal, was found in operation. At Arkalon the work of construction was not completed, and water had not been found in sufficient quantity to operate the factory had it been ready for work. At Meade attempts were still making to secure water. At Minneola, where the roasting process was on trial, no water was available, but a few pounds of cane were passed through the furnace to show its mechanism. At Attica and Medicine Lodge the factories were found in operation, and at the latter place we found the only sufficient water supply of the stations receiving aid from the Department. At Conway Springs the factory was really shut down for lack of water and for some repairs, but was set in motion temporarily for inspection by the Secretary. At Fort Scott the factory was found to be running smoothly. The original machinery placed in this factory by the Department is still largely in

use, and the proprietors expressed their entire willingness to place all desired data in the hands of the Department.

The general impressions derived from this hasty tour of inspection were that the southwestern part of Kansas is too dry for growing sorghum for sugar under the present methods of culture, that the factories in that portion of the State had been mostly located without proper consideration of the water supply and possibilities of the soil and climate; that the crop of cane throughout the southern central part of the State was exceptionally fine and contained large quantities of available sugar, and that the factories in the part of the State last mentioned were far inferior to the capacities expected of them, with deficient machinery, in many respects incapable of continuous work, and with one exception operated with an insufficient supply of water. In general it appeared, from what could be observed, that financial success could hardly attend the present season's work, and that this unfortunate condition of affairs might have been avoided by the wiser investment of a larger amount of capital directed by a more judicious and extended experience.

REPORTS OF WORK AND OBSERVATIONS.

In order to obtain as much information as possible on all points connected with the sorghum sugar industry each of my assistants was directed to report to me in full the results of all analyses, facts disclosed by chemical control of manufacture, and all data relating to the crop, quantity of cane grown and purchased, loss in cleaning cane, sugar and molasses made, cost of manufacture, and all other data of a nature to elucidate the problem of sugar making. These reports[1] will be found appended to this bulletin.

It is due to the young men who had charge of the work at the various stations to say that a large part of the data collected was obtained by disregard of the conventional hours of official labor. A culture station or a sugar factory would have little use for a chemist who would refrain from presenting himself at the laboratory before 9 o'clock a. m., and at 4 o'clock p. m. promptly stop his work.

MANUFACTURE AND CHEMICAL CONTROL.

REPORT OF WORK AT CEDAR FALLS.

In addition to the report of the chemist, Mr. A. E. Knorr, of the work done at Cedar Falls, there is given the report of Bozarth Brothers, who had charge of the technical part of the experiments.

I can not add anything to the discussion of the data obtained at Cedar Falls more pertinent than a selection from the report made to the Secretary in June last.

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[1] On account of insufficient funds to print the whole of the report on sugar these reports are printed by abstract only. For the same reason only a small portion of the body of the report as originally prepared is found in this bulletin.

REPORT OF THE PROSPECTS AT CEDAR FALLS, IOWA.

"Clinton Bozarth and sons have for several years conducted very successfully a factory for the manufacture of sorghum sirup at Cedar Falls, Iowa. The company owns a well-equipped factory and about 100 acres of land situated on the left bank of the Cedar River, immediately opposite the town of Cedar Falls. The soil is very sandy and appears well suited to the growth of sorghum. The company has this year planted about 100 acres of their own land and have contracted with adjoining farmers for about 200 acres more. Three hundred acres of cane usually afford a sufficient amount of raw material to keep the factory in operation from twenty to twenty-five days. During the past season 40,000 gallons of molasses were made and sold at a fair profit. Some seasons, however, the cane is killed by frost before it has matured and the output of molasses is very much diminished in quantity and also inferior in quality. Killing frosts are usually expected early in September. Cedar Falls is situated in the northeastern portion of Iowa in the latitude of Dubuque. I have no hesitancy in saying that all expectations of ever successfully establishing a sorghum sugar industry in such a locality must end in disappointment. The company has a fairly good mill, a Louisiana No. 2, manufactured by George L. Squire, of Buffalo, N. Y., and convenient pans for clarification and evaporation of juices. The factory is without doubt one of the best appointed in the United States for the manufacture of sorghum sirup. I regret exceedingly that the proprietors have acquired the idea of making sugar, since, as I said above, it will be quite impossible for them to succeed from a commercial point of view. Some seasons, however, the cane is quite rich in sugar and large quantities of molasses have granulated and several thousand pounds of sugar have been made by separating these crystals from the molasses in a centrifugal machine. Perhaps one reason why the members of this company have been led to believe that they could manufacture sugar successfully is on account of a recent report issued by the Agricultural Experiment Station of Iowa, in which the profitable manufacture of sugar in that State is regarded as a possibility. The financial difficulties which such a report might cause by encouraging the investment of capital in hopeless enterprises could possibly be very great. I discouraged the members of the company in so far as possible from undertaking such experimental work in that locality, but did not succeed in convincing them of the impracticability of the endeavor. They are very much inclined to go ahead with the $5,000 which have been conditionally promised them by the Department, and erect a small vacuum pan and centrifugal plant for the purpose of making these experiments. I assured the company that the Department would not probably aid it to a greater extent than $5,000, and asked them to make a statement of the probable cost of the experiments and see if they could be made within the sum specified.

"I greatly fear that should the company undertake the experiments the cost will be greater than the estimates and that therefore the venture will be a source of financial loss instead of profit; nevertheless, I have laid before them the dangers which they will undergo and the difficult character of the work which they are to undertake, and if they enter into the matter it will be after full information in regard to all points on which they should be placed on their guard."

REPORT ON WORK DONE AT RIO GRANDE.

In Mr. Horton's report of the work at the Rio Grande station will be found an extension of the general report on operations at this place during the past eight years contained in Bulletin No. 20. The analytical data of each year were copied by Mr. Horton from the record books of the station kindly placed at his disposal by Mr. Hughes.

The most discouraging feature connected with the Rio Grande experiments is found in the deterioration of the cane for sugar-making purposes. For several years in succession the cane crop at Rio Grande has been unfit for making sugar. The causes of this deterioration are not easily discovered. Careful inquiry fails to show any exposure to admixture with broom-corn, a cause which according to Leplay led to the total failure of the sorghum plant in southern France. It is possible that the habit of fertilizing at Rio Grande to secure a large tonnage may have led to some depreciation of the sugar content of the crop. The character of the climate may have also had something to do with it. It is now firmly established that sorghum develops its maximum content of sugar in a season with little rain, which is a condition of a maximum quantity of sunlight. The records of the signal stations appended to Mr. Horton's report show that during the years in which observations were made these conditions of maximum richness in the cane were not always fulfilled. Experience has further shown that the largest and finest seed heads do not make the richest canes, yet it is a natural custom to select the finest looking heads for seed. This mistake will be remedied just as soon as the production of seed for planting and the growing and manufacturing of the crop shall have become separate fields of labor, as they must necessarily be. The quantity of seed required to plant an acre of sorghum is so small that both farmer and fabricant can well afford to purchase scientifically selected seed at a high price.

The method which should be pursued is the following: A single seed head from a cane of high available sugar content should be planted apart from all possible danger of admixture. There will then be produced a large number of canes of great uniformity of character and of high sugar quotient. The seed from their growth will be sufficient to plant many acres. Every field of cane grown for sugar-making purposes should be thus produced, since it would be impracticable to furnish the requisite quantity of seed directly from the polarized canes. The

great advantage that would accrue to the sorghum sugar industry from this method of seed selection is apparent without further elucidation.

On account of the low sucrose in the juice no attempt was made to manufacture sugar except from cane from a few small areas which indicated a sufficient quantity of sugar to secure crystallization. In the case of the small area which furnished the 2,900 pounds of sugar made, it is difficult to see why the cane in that portion of the field was saccharifacient, while in other portions, where all conditions were apparently identical, it was not so. This is another illustration of the vagaries of the sorghum plant, to which I have often called attention, and which serve to characterize it as one of the plants most susceptible to variation known.

From the small area of 2.9 acres in the upper end of the Morris Cresse field, 31.9 tons of cane (whole) were harvested. The mean content of sucrose in this juice was 11.14 per cent. On the basis of 88 per cent. juice in the cane, each ton thereof contained 1,760 pounds of juice. The percentage of extraction in the battery during this run was about 83 per cent. The total sucrose per ton of cane was 196.1 pounds. There was obtained per ton 99 pounds, polarizing 85 degrees=77.3 pounds pure sugar per ton. The loss of sugar in the battery in manufacture and in the molasses amounted to 118.8 pounds per ton.

No other attempts were made to produce sugar, although two other sections of the same field showed a sufficiently rich cane for that purpose. One of these produced cane yielding 10.67 per cent. and another 9.67 per cent. sucrose in the juice. These canes, however, were not worked for sugar. Inasmuch as over 200 acres were cultivated in cane and only 2.9 acres of this worked for sugar, the net result of the season's work, in so far as sugar-making is concerned, was decidedly negative in character.

The results of the last three years' experimental work at Rio Grande clearly demonstrate the fact that the only hope of successful sugar-making from sorghum in southern New Jersey must rest upon the production of cane decidedly richer in sugar than the average crop produced at that place since a record of its character has been kept. The character of the climate and soil would indicate that the sugar beet might be very successfully cultivated, and it would be extremely interesting to have some comparative experiments made with that plant. There are many reasons for expecting that the results of such experiments would be of the most hopeful character.

MACHINERY USED AT RIO GRANDE.

The machinery used at Rio Grande was of the same general type as that described in Bulletin 20. The battery constructed on the Hughes system of open cells and dipping baskets was entirely new and of greater capacity than those heretofore used. Many of the mechanical difficulties encountered in operating the first batteries of this kind

were remedied in the new apparatus, and its work was smooth and generally satisfactory during the entire season. The mean percentage of sucrose left in the chips as far as determined for the season was about 2.5 per cent. Based on the usual data this shows a mean extraction of 80 per cent. A special trial of the capabilities of the battery under the most favorable conditions was made on October 12. The mean weight of chips in each basket was 307 pounds. The mean quantity of water in each cell 368 pounds; the time of contact, *i. e.*, the time each basket remained in cell before transfer to next cell, was one and a half minutes, during which time the basket was dipped twice in the same cell. In the Hughes battery, consisting of ten cells, there is an additional cell called the eleventh, extraneous to the others, and into which the juice is drawn from the main battery. Into each charge of juice thus drawn the basket of chips next to be introduced into the battery is introduced and allowed to remain for one minute. The temperature of the juice in the eleventh cell was about 208° Fahr. The consequence of this immersion is at first the enrichment of the juice by contact with the fresh chips. These chips, however, enter the circuit of the regular battery with a less content of solid matters proportionate to the quantity given up by the first immersion. The final result must be to dilute the juice of the main battery to the extent of the matters extracted by the eleventh cell. In other words, the main battery works constantly on impoverished chips and the concentration of the diffusion juices therein is diminished to that extent. The final result of this process is therefore exactly the same as working with eleven cells in regular circuit. There is no compensation for the complicated mechanism of having one of the cells in a separate circuit.

The whole system of open-diffusion cells—which by the way was the first form of diffusion apparatus used—has long since been shown to be inferior in every respect to the closed system; and there is no conclusive evidence from the present year's experiments of any feature either of economy or advantage in the cost and operation of the apparatus. Designed originally to make sugar making economical on a small scale, it has gradually expanded into proportions of considerable magnitude without having given any indications of its ability to secure the original aim.

In fact there is now no more evidence than formerly of the possibility of manufacturing sugar economically on a small scale.

It is our duty to speak positively on this point. Every attempt to produce sugar on the farm or by combination of a few farmers must at present end in disaster, and there is every reason to believe that the future will show no greater encouragement to small factories. The manufacture of sugar requires such extensive and costly machinery as to relegate it to individuals or corporations with large capital and expensive apparatus.

Three seasons of experiment with the Hughes system of small fac-

tories have only confirmed the original views expressed from this office and serve to emphasize more strongly the absolute necessity of the best machinery constructed on the line of two great principles of sugar manufacture, viz, closed extraction apparatus and evaporation in vacuo. With our present knowledge it must be said that all attempts not falling within these lines must end in failure. To the farmer I say, content yourself with producing a crop rich in sugar and as high in tonnage as can be to obtain the object just named. To the manufacturer I say, use the best forms of closed diffusion batteries, simple clarification with lime, and the best methods of evaporation in vacuo.

There is one condition, however, in which I see a possibility of usefulness for the Hughes system of diffusion. There are two considerations which are kept in view in the extraction of sugar, viz, (1) the completeness of the extraction and (2) the density of the extracted juice. Theoretically the density of the diffusion juice can be made equal to that of the juice in the cane by an infinite number of cells in the battery, or an infinite number of dips in the Hughes apparatus. At first in starting a battery the hot water is speedily charged with the solids in solution in the cane cells, being brought into direct contact with the normal chips. In the regular running of a diffusion battery quite a different condition obtains. The extracted juice is brought only once into contact with fresh chips. We may regard normal diffusion as such a conduct of the work as allows complete equilibrium to be established between the circumfluent and intercellular juices, which in each case are equal in volume. The rate of diffusion depends, as is well known, on the size of the chips and the temperature of the juice. The smaller the chip and the higher the rise of temperature the more speedily will this equilibrium be established. The size of the chip, however, has more influence on this operation that the temperature. The theoretical normal diffusion would take place in a single cell surrounded by the diffusion juice. The superposition of cells such as is found in the ordinary cane chips and beet slicings entering the battery requires that the diffusion should take place in the exterior layer of cells and from one direction before it can begin with the interior layers. The time required for the diffusion through a single cell wall containing within a solution of sugar is not instantaneous but extremely minute. But the sum of the intervals required for the penetration of hundreds of cells successively becomes quite large.

In a normal diffusion of twelve contacts or twelve dips the relative concentration of the diffusion juice compared with the original juice in the cells of the plant can be calculated from the formula given in Bulletin No. 2, page 10. In practice, however, a larger quantity of liquid is used than in normal diffusion and the time of contact is not long enough in each case to secure complete equilibrium. With the apparatus now in use, therefore, we can not hope to obtain a relative density between diffusion and normal juice of more than 80 to 100. Any proposition

looking to the procuring of normal diffusion juice by allowing the time of contact to be extended beyond reasonable economic limits must be rejected for practical reasons. By reducing the size of the diffusion chips the normal diffusion juice can be more readily obtained. In the case of the beet, by reducing it to a fine pulp the normal juice, *i.e.*, complete equilibrium, is obtained in so short a time as to be practically instantaneous. On this fact Pellet has based his process for the instantaneous analyses of the beet by the aqueous method. No rise of temperature is required for this purpose, the equilibrium being established almost instantly in the cold. Sugar canes, both sorghum and sugar cane, reduced to a fine pulp would act in the same way. The mechanical difficulties of doing this are much greater than in the case of the beet on account of their more fibrous structure.

Nevertheless a cane shredder might be constructed which would furnish a pulp approximating in fineness the beet pulp above mentioned. In applying such a process practically, however, a point might be reached in the ordinary battery where the fineness of the chips would impede and finally prevent the circulation. This would arise from the fact that the pressure in such a battery is always in the same direction save in the first filling of the cell. The almost solid pulp thus formed might be more or less impervious to the circulation of the diffusion liquids. Now, if such a fine pulp can be produced in an economical way, it might be worked to great advantage in the Hughes battery. In dipping the basket into the cell of liquid the pulp would be raised and loosened and the perfect mixture of the pulp and liquid would be at once secured. The diffusion would take place almost instantly, the baskets could be quickly removed, and a small battery be made to do a great deal of work. In such a case I can easily see how a Hughes battery might be made to operate in a successful manner. The fact that such a diffusion could be carried on at ordinary temperatures would allow a purer juice to be obtained, since at high temperatures starch is rendered pasty and pectic substances rendered soluble.

Normal diffusion as described is secured when the added diffusion water is exactly equivalent in volume to the volume of juice in the substance under diffusion and where temperature and time of contact are so adjusted as to secure in each case complete equilibrium between the crystallizable bodies in the intercellular substance and the circumfluent liquid. When, therefore, it is claimed that diffusion juice of equal density with the intercellular juice is obtained in chips of the size usually employed it is at once evident that the operation has been carried on in some abnormal way, or that some factor in the process has been omitted. In the case cited in Mr. Horton's report it seems that the diffusion juice was almost equal in density to the normal juice in the cane chips employed.

The mean temperature of the cells during the trial run was 97° C. and the total time of contact seventy-two minutes for each cell. The enor-

mous surface exposed in the cells and by the chips when lifted, and by the juice dropping back into the cells from the uplifted baskets, doubtless cause sufficient amount of evaporation to account for this abnormal result. To work the battery in the way taken to secure the result would be far from economical and the results obtained are interesting more from their abnormal than practical interest.

CULTURE EXPERIMENTS AT RIO GRANDE.

In addition to the manufacturing experiments at Rio Grande some interesting data were collected concerning culture. A special plat of ground comprising several acres was laid out in plats and planted with some thirty varieties of seeds grown by the Department at Sterling. Unfortunately the seeds were found to be mixed, and although a vigorous growth on all but a few plats, yet owing to the admixture above noted and the lateness of the season no analytical examination of these plats was undertaken. Some most interesting problems were presented in connection with the Morris Cresse field. This field is fully described in the appended reports.

The time between plowing the upper and lower end of the field was only four days, and this interval can hardly account for the great difference in the composition of the cane grown on the different sections. The cane was harvested in six sections and the mean content of sucrose in the juice from each section, beginning with the upper end of the field, was 7.62, 8.09, 7.25, 9.67, 10.67, and 11.14 per cent. respectively.

The expectation of Mr. Hughes to compensate for late plowing and a consequently short season by nitrogenous fertilizing is a rather surprising one. The well-known properties of nitrogen in promoting vegetation and consequent longevity of the plant would lead us to expect just the contrary effect described by Mr. Hughes. A quick-maturing plant, though one yielding, of course, less tonnage per acre, would have been secured by growing the crop in unclovered fields and with a fertilizer in which phosphorus and potash were the predominant elements. Considering the late plowing and the wet season a more unfortunate selection of fertilizer could hardly have been made. It may be that the low sucrose content appearing in the Rio Grande canes during the past few years is partly due to the prominence given nitrogen in the fertilization. Yet, on this point no statements can be made with authority, but only by inference, for the history of fertilizing sorghum is still too young to form a basis for any practical conclusions. The results of a single season's work in such a case can only be accepted as indicative and not as final. Many years of varied trial in seasons of every kind and on diversified soils must elapse before a final judgment can be formed. The beginning made in New Jersey is valuable and will doubtless lead in time to more valuable theoretical and practical results. The variations in the sugar content of the various sections of the field illustrate

the difficulty heretofore encountered in obtaining sorghum of high uniform character for manufacturing purposes. In uniformly dry and mild seasons, such as have been experienced in Kansas during the past two years, a reasonable degree of uniformity has been reached where the samples have been taken over widely extended areas. In less favored localities all hope of securing such uniformity, it seems, must be abandoned. The culture results at Rio Grande serve to confirm the opinion hitherto expressed by me that the area for successful sorghum sugar growing is a restricted one, and that in the work of the last three years in central Kansas most valuable indications have been obtained of the probable location of the most favorable soil and climate for sorghum. This opinion is not expressed to deter any one from making culture experiments in other localities, but rather to call attention to the most promising field of operations. Sorghum at present is so far inferior to the sugar beet and sugar cane as to require the help of the most favorable soil and climate in order to maintain its existence as a sugar-producing plant It is the part of wisdom in such cases to follow the most promising path and to leave the more difficult ones for future explorations.

MANUFACTURING WORK AT MORRISVILLE.

The results of the manufacturing trials at Morrisville are tersely summarized by Mr. Maxwell at the close of his report in the following words: "If a remunerative crop had been produced the mill was not in order to work it, and if the mill had been ready to work there was not a crop to be worked."

The mill was hastily constructed and presented in rather an unusual degree the difficulties attending the trials of new machinery.

The battery on the Hughes system was designed to have a capacity of 45 tons of field-cane per day, but, by defects in the machinery for cleaning and shredding the cane, rarely more than 20 tons were worked. No sugar whatever was made and the molasses manufactured was of a very inferior quality. It is the old story so familiar in sorghum literature—imperfect machinery, disastrous delays, vexatious accidents. Surely the science of mechanics and the skill of the machinist were never so coy with any other industry.

CULTURE EXPERIMENTS AT MORRISVILLE.

The result of the culture experiments at Morrisville is rather the record of the successive disastrous floods which prevailed over the cis-Alleghanian part of the United States during the season of 1889 than of any valuable information gained.

The agricultural part of the work at Morrisville was probably only exceeded in crudeness by the character of the machinery provided. We find a history of partial plowing, dodging of stumps, planting in

mud, cultivating in rain, and gathering a scanty harvest out of a wilderness of weeds. The chemical data tabulated by Mr. Maxwell show without further comment the character of the crop produced. It is gratifying, however, to note that on many farms adjacent to the plantation of the Virginia company crops of sorghum were produced which in some instances with careful manufacture would have yielded a fair return of sugar. Yet it is scarcely probable that the soil and climate described by the report will be able to compete with the broad and fertile fields and genial suns of central southern Kansas and northern central Indian Territory and Oklahoma.

MANUFACTURING EXPERIMENTS AT KENNER.

The manufacturing experiments at Kenner were conducted on a small scale and are to be considered rather as the completion of the culture experiments than an attempt to produce sugar economically. The percentage of sugar in the cane recovered in the diffusion juice was uniformly high, the sugar left in the waste chips amounting to only about .3 per cent. The fine work of this small battery furnishes a continued demonstration of the merits of this system of diffusion first set forth for sorghum in Bulletin No. 2, and shows its immense superiority even for small workings over the system used at Rio Grande. The capacities of the two batteries are almost the same. Allowing 25 pounds of chips for each cubic foot of space in the Kenner cell, the total capacity of each cell in pounds is 337.5, which is practically the same as the baskets at Rio Grande. When the convenience of heating, the ease of charge and discharge, the saving of energy in moving the diffusion juices instead of the whole system of baskets with their loads of chips are taken into consideration the preference even for a small factory must be accorded to the closed system of diffusion. Another practical point is of importance. In the experiments at Kenner considerable quantities of sugar were obtained from canes quite as poor as those worked at Rio Grande, and which by the system there used gave no sugar whatever. This fact, however, was not needed to demonstrate the danger of working cane juices for sugar without neutralizing their natural acids and by evaporating them to sirup in open pans. The work at Kenner shows that, by careful treatment and proper technical and chemical control, sugar can often be made from juices of an almost hopeless poverty.

The danger of allowing sorghum canes to remain exposed to hot suns after cutting has long been recognized. Some of the manufacturing data at Kenner would seem to indicate that the danger has been magnified. The cane shipped from the plantation of Mr. Maxwell may be taken as an illustration of this. After nearly a week of exposure it was found to have suffered but little inversion. It may be, however, that the cane was exposed in a pile of considerable magnitude, and in such cases the interior canes are protected. Again it must not be forgotten that these canes suffered such injury in passing through the battery as

to render them practically unfit for sugar making. The general result of the work at Kenner in respect of the inversion of sorghum cane forms no certain evidence of immunity from danger by omitting to deliver sorghum cane at the factory directly after it is harvested. Perhaps a delay of twenty-four hours may be contemplated without alarm, but a greater certainty of a large sugar product will attend the direct transfer of the cane from the field to the factory. The difficulty of purging sorghum massecuite in the centrifugals is not one peculiar to Louisiana, through it perhaps exists there in a greater degree than in Kansas. Uniformly canes poor in sucrose and of low purity furnish a massecuite difficult to dry. This defect is one of great annoyance to the manufacturer, who is obliged to supply his factory with a centrifugal surface out of all proportion to the yield of sugar. The observation of Dr. Stubbs, however, is doubtless correct that sorghum grown in a warmer climate develops a greater quantity of gums and affords a massecuite of a more refractory nature. Sorghum grown in high northern latitudes appears to have a higher purity than that grown father south, and experience must decide how far purity of juice must be sacrificed to length of season.

In point of fact the difference in seasons between central southern Kansas and northern Louisiana is so slight as to lead to the belief that the sorghum sugar industry might be profitably introduced in the latter locality.

Both the culture and manufacturing results obtained at Kenner from sorghum canes grown in the sugar-cane belt confirm my previously expressed opinion that a soil and climate suitable to the production of sugar-cane are pooly adapted to the production of sorghum sugar. (Bulletin 20, p. 11.)

The low tonnage and refractory nature of the sorghum heretofore produced on sugar-cane lands afford no reasonable hope of an economical supplementary or preliminary season of sorghum in cane sugar factories.

It must also be noted that if the drying of the sugar is to be attended with difficulties described in the Kenner report, all hope of establishing the industry even in northern Louisiana must be abandoned. It seems reasonable to suppose, however, that with a large strike-pan permitting the building of a larger crystal the delay in drying the sugar can be very much reduced.

In the light of these experiments made on a small scale, it would be rash to invest capital in northern Louisiana in a sorghum sugar factory. Future experiments, however, may be able to show more favorable data.

CULTURE EXPERIMENTS IN LOUISIANA.

The general results of the culture experiments carried on in Louisiana corroborate the data obtained at Sterling in respect of the generally valueless character of the new varieties of sorghum. The best results in

general are shown with the standard varieties which have been chiefly cultivated during the past few years. There are, however, some notable exceptions to the rule both as regards time of maturity and sugar content.

While, therefore, most of the work in testing new varieties is of a nugatory character, there have been obtained in particular cases results which justify the wisdom of extensive trials. A notable example of this is shown in No. 6 of the varieties grown at the Baton Rouge station, described as No. 39 from South Africa, and which gave a juice having the following composition:

Total solids (Brix) 19.7 per cent.; sucrose, 15.6 per cent.; glucose, 1.28 per cent.

A single seed head from such a variety would furnish seed in the third year to plant cane extensively, and could the juice from such cane be worked as well as sugar cane juice, it must yield easily 200 pounds sugar per ton. The culture experiments at Baton Rouge were in some respects the most interesting of all those conducted in Louisiana. The seeds planted at the station were grown by the Department last year at Sterling and it was hoped to secure a large number of comparative trials with them in different parts of the country. The misfortunes which attended these trials at Rio Grande, Morrisville, and Conway Springs have been noted.

The observation made by Dr. Stubbs in respect of the value of the Links' Hybrid variety is corroborated by experience in Kansas and other places. Practically the several varieties of sorghum known as Orange with its nearly related subvarieties have been found to be the most valuable for sugar-making purposes, but the analyses given in the report would certainly justify the preference given to the Links' Hybrid in comparison with several other varieties, but practical trials must be awaited before a final decision can be reached.

The improvement in existing varieties which may be secured by the methods inaugurated in our culture experiments and carried out on the lines of investigation marked out will certainly lead not only to the permanent development of canes with higher sucrose co-efficients and lower glucose ratios, but also with lower content of starch, amylo-dextrines and gums, and other bodies interfering with successful manufacture.

MANUFACTURING EXPERIMENTS AT CONWAY SPRINGS.

The first and most radical mistake made by the management was in attempting to remodel the old factory. The first factory was a striking illustration of the surprising degree of unfitness of means to ends which can be secured by insufficient capital, assisted with lack of mechanical training, deficiency in engineering skill, and dearth of time for preparation. Industry, ability in other directions, and deep enthusiasm for the work could not offset the deficiency.

After the expenditure of nearly or quite $30,000, however, it was shown by the season's work that the new factory was little if any superior to the first. The meager record of but little over 4,000 tons of cane worked during a long and favorable season is a true but complete story of almost total inefficiency. During all this time, as Mr. von Schweinitz has set forth, the expenses connected with the work were quite or nearly as great as if the factory had been working up to its full estimated capacity.

In a dispassionate review of the manufacturing work of the place it seems to me patent that could the factory have worked regularly 200 tons of cane per day, the end of the season would have disclosed a handsome profit. It certainly is not unreasonable to ask for a factory which can do this the season through. Yet it must be confessed that the sorghum sugar industry has never had the help of such a factory. It has never had a fair chance from a merely mechanical point of view. One source of weakness at Conway Springs deserves more than a passing notice, viz., the insufficiency of the water supply. This was one of the greatest difficulties besetting the first season's work as has already been noticed in Bulletin 20. Within a mile of the spot where the factory was built is a stream of good water which would have proved abundant for even a much larger factory; yet both old and new factory were built without considering the absolute necessity of abundant water. A wise capitalist, seeking a safe investment for his money, had he decided on building a sorghum factory would have located it on the banks of the stream. But the town of Conway Springs voted public bonds ostensiby to build water-works, but in reality as a bonus to the sugar company. Therefore the factory was built rather to secure the bonds than to make sure of an abundant supply of water. As a result the town has been supplied with a saturated solution of gypsum masquerading under the name of water and a bewildering agglomeration of tanks, pulleys, pumps, and débris has been operating as a sugar factory. Such will continue to be the history of bonded sugar-houses built without design and operated without aim.

These strictures, apparently severe, are not made in any personal sense. The promoters and builders of the factory doubtless acted in accordance with the dictates of their judgment, and there is no question of their honesty of purpose. It was simply impossible to build and operate a sugar factory under such auspices, and it would have been the part of wisdom to have refrained altogether from the attempt. The record of the chemical control of manufacture at Conway Springs is of the highest interest. Again as last year the cane crop at Conway Springs was the best suited to sugar-making of any in the country. The mean percentage of sucrose in the juice of the chips entering the two batteries for the present season was 11.98 against 12.42 for the preceding season. The per cent. of fiber in the chips was 11.49, giving a juice percentage of 88.51. The total juice in the cane was therefore 1770.2

pounds per ton, and the quantity of pure sucrose 231.1 pounds per ton. Especially encouraging are the results of the trial run in the four days mentioned in the report during which the machinery worked fairly well, averaging 150 tons of cane per day. During this time it was clearly demonstrated that a fair profit could be made, selling first sugars at 6 cents per pound and molasses at 10 cents per gallon. The achievement of four days may easily be made the history of a whole season, and even with better results. In such a soil and climate, and with such a factory as abundant capital and proper skill might supply, the sorghum sugar industry might flourish without the aid of the State bounty. When we take into consideration the burdens with which the season was commenced, the inexperience of the managers, the crampings of insufficient capital, the internal dissensions of the company, the shortness of the water supply, and the defects of the machinery it must be confessed that the company has made a good showing and deserves praise for its heroic struggles. Its record of two seasons has shown to intending inventors the best sorghum-cane region in the State or the country, and there is abundant water in the county by which to build a first-class factory.

CULTURE EXPERIMENTS AT CONWAY SPRINGS.

The slight decrease in the percentage of sucrose in the juice of the canes of Conway Springs as compared with the season of 1888 is probably due to the cause assigned by Mr. Von Schweinitz, viz, a better season for growth, producing a much larger tonnage and juicier canes.

It was gratifying to note that the total substances, not sucrose, in the juice decreased in a somewhat greater proportion than the sucrose, thus securing a slight gain in purity. It will be interesting, however, to watch the sucrose content of the cane for several seasons to see if it continue to show the same high qualities. The special plot culture experiments were made subsidiary to the regular crop work, and hence were rendered valueless for comparative purposes. The mixed character of the canes growing on these experimental plots was another illustration of the danger of planting seeds taken from a whole plot and from canes grown from unselected seeds. The value, however, of even a partial beginning in scientific seed selection is shown by the history given of the amber cane. Not only Conway Springs, but also Attica and Medicine Lodge, were benefited by this selection. The high sucrose co-efficient obtained at Conway Springs during two successive years marks this locality one of the best yet discovered for sorghum growing. Within a radius of ten miles from the village thousands of acres of land could be planted to cane, and a stream of considerable magnitude flowing through the center of this area would supply the water required by several factories. The methods of cultivation employed are of the simplest kind. It is reasonable to suppose that with deeper plowing or subsoiling the crop would be more successfully brought through a very dry

season, and that a more careful cultivation would not only increase the tonnage, but also the sugar co-efficient. The mean content of sucrose in the chips entering the two batteries shows a crop having, over wide areas, a pretty uniform value. The usual violent variations in individual canes, however, are found in the table giving the composition of the juices from single canes. In all cases the purity is based on the total solid matters in the juice as indicated by the Brix spindle. The true purity is really about 10 per cent. higher than this, since it has been shown that the Brix spindle reads some 10 per cent. higher than the actual quantity of solids in solution.

MANUFACTURING EXPERIMENTS AT ATTICA.

The most striking feature of Mr. Carr's report is the statement of losses in manufacture. The next point—probably it should be first—is the old story of imperfect machinery. When the actual working capacity of the factory is compared with the estimates placed upon it by the builders before the manufacturing season opened it will not be a matter of surprise to read of the financial disasters attending its operation. The quantity of field cane which it was designated to work was 250 tons per day. The actual quantity used was less than 100 tons. The crop which the farmers were induced to plant was large enough for the estimated capacity. The delay, worry, and loss from an agricultural point of view, due to deficient capacity, need not be described.

It is strange to note that one of the weakest points in the house was found in the multiple effect vacuum pan. As Mr. Carr justly remarks, this style of apparatus has long since passed the experimental stage. I have noticed a strange tendency among those about to embark in sorghum work to adopt new and untried devices for old and reliable processes. It is true that such processes are very often great improvements on those now in use, but they should never be depended on to save a great financial venture until they have been thoroughly tried. Thus in sorghum factories have been seen diffusion batteries of new design and novel arrangement, pumps of peculiar construction, boilers of unknown possibilities, and evaporating pans heralded only by the unproved claims of their inventors. The readiness with which many, perhaps nearly all, who have devoted themselves to sorghum listen to golden tales of profit, the perversity with which they shut their ears and eyes to the plainest evidence of impending difficulty, the alacrity with which they take into their confidence the boomer of bonds and the maker of machines, are some of the most discouraging features of the industry. It is high time that the era of blind enthusiasm be passed, and it is quite late enough for men to look at sorghum as they do at iron or wheat.

The heating surface required for evaporating sorghum diffusion juice is greater, *caeteris paribus*, than for sugar-cane and beet juices. This

arises from the readiness with which the lime salts and gums coat the copper tubes. In order to secure good results the apparatus should be boiled out every two or three days with soda-lye, and diluted sulphuric acid, or thoroughly scraped. The capacity of the pan should be large enough to permit this necessary cleaning without impeding the regular working of the house. Approved patterns of pan should be used of a kind to avoid loss of sugar in the condensation water, and permitting easy cleaning. A pan which would evaporate 50,000 gallons of pure water in a day might fall far short of evaporating 50,000 gallons of water from diffusion juice.

The great loss of 35 per cent. of the weight of the cane in cleaning is also to be noted. The mean percentage of leaves and seed heads on the total weight of the cane in its maximum maturity is about 25. In a climate like that of Attica, where the lower leaves especially become dry, the weight of leaves and tops for the whole season ought not to be greater than 20 per cent. of the whole. When it is further remembered that much of the crop is worked after frost this number becomes even less. The loss above noted must therefore have arisen from cutting the stems of the seed heads too long or by blowing out the short sections of the cane in the cleaning apparatus. There is no possible excuse for such a loss, since it is not difficult to arrange a cleaning apparatus in which these losses can be avoided. The loss of sugar in the exhausted chips points to some fault in conducting the diffusion which could be easily remedied. The tendency to set the shredding machines to cut larger chips as the season advances is one which should be promptly resisted. The extraction during the first period of work was almost too low for satisfaction, but when the percentage of sucrose in the exhausted chips during the second period was allowed to run up to 1.57 the process became a travesty. During this period also the greatest quantity of cane was worked. Such poor work is calculated to bring discredit on the whole process. The loss of sugar passing into the molasses is largely beyond the control of the fabricant, yet skillful boiling and careful manipulation in the hot room and at the centrifugals will reduce this loss to a minimum. On account of the difficulty with which sorghum massecuite is purged it will be found advisable in my opinion to make the hot room of the factory of large capacity, large enough if possible to hold a week's run, and keep it at from 110° to 120° Fah. The sugar which would pass into the molasses on direct centrifugalling from the strike pan would be largely crystallized and saved by seven days standing in the hot room. The objection to such a course would be the large hot room and great number of sugar wagons required. It resolves itself into a question of economy which can only be answered by experience.

The experiment of filtering the diffusion juice by keeping it at the boiling point with a jet of live steam succeeded beyond all expectation. Mr. Deming deserves great credit for persevering against great diffi-

culties in this matter. The juice evidently suffers considerable dilution by the process and the quantity of foreign matter removed is small. None of the soluble lime salts nor gums that subsequently coat the evaporating tubes and clog the centrifugal sieves is removed by this filtration and it is an open question whether it will prove to be an economical process. Since the only beneficial effect of the steam jet is secured by the rise of temperature, it might be well to inquire, in case filtration should be deemed advisable, whether this might not be secured in some more economical way.

The study of the inversion in the battery forms an interesting chapter of the report. The inversion is naturally computed from the glucose ratios of the fresh chip and diffusion juices. The uniformly mean increase in the glucose ratio may arise from actual inversion of the sucrose during diffusion or to the more ready diffusibility of the reducing sugar. These sugars, however, being less crystallizable than sucrose would lead us to suppose that they would not be more diffusible. It is therefore probable that some of the sucrose is inverted during the process of diffusion. On the other hand it is well known that the organic acids, even acetic, act on dilute solutions of sucrose very slowly, and therefore the total effect in any case must be small. The additional fact that even when the diffusion juices are made neutral by the continuous addition of lime, the glucose ratio is often increased tends to show that sucrose in presence of the lime salts, reducing sugars, nitrogenous bodies and ferments in the juice may be slightly inverted during diffusion. In the Attica experiments it appears that the invertive effect occurs most actively with unripe canes, as is shown by the data from the September run. The inversion which occurred during the other two periods of work was of little importance from a commercial point of view. With the use of a finer chip and a more rapid operation of the battery it would be possible to reduce this inversion to a minimum. The mean temperature of the inner cells of the battery at Attica was about 65°. C and the mean time each charge was under pressure in regular work about two hours. The numerous delays, due to imperfect machinery and insufficient evaporating surface, unavoidably prolonged the time of pressure, but in such an irregular way as to prevent any accurate study of the effects produced. The purity of the diffusion juice is somewhat higher than that of the chip juices, showing that, notwithstanding the increased glucose ratio, a more than compensating quality of other substances was left in the exhausted chip. This was probably due to the low temperature in the battery. This purity, increased by the percentage necessary to correct for the actual solids present in solution, is a very encouraging number. The fact that with such a purity and with good filtration so poor a yield of sugar per ton was secured lends additional emphasis to the statements of the great losses suffered during the course of manufacture. The careful manner in which Mr. Carr has located these losses is worthy of

especial commendation, and shows in a most striking manner the value of chemical control. In the statement of cost of manufacture the fixed charges for taxes, insurance, interest on investment, and wear and tear of factory are omitted, as was also the case with the statement for Conway Springs.

When these charges are taken into consideration the apparent profit in the one case vanishes, and the cost of the sugar per pound in the other is materially increased.

CULTURE EXPERIMENT AT ATTICA.

About 10 acres of land were set apart for special culture experiments and attention to these plots was assured by employing special labor to take charge of it. In this way careful culture of the plots was secured. The seed derived from the Sterling station, as in the other cases, was found to be somewhat mixed.

In the general work some additional data of great value from an agricultural point of view were obtained. The composition of the juice from the samples of different chips for September showed 9.75 per cent. sucrose, 2.29 per cent. reducing sugars, and 15.96 per cent. total solid matter in solution. This matter, as is also the case in all the tables, was determined by the Brix spindle and is about 10 per cent. too high. Although Mr. Carr states that much of the cane worked during the period was immature, yet the mean results of the analyses show by no means a poor character of cane. With careful manufacture from 70 to 90 pounds first and second sugars should have been obtained. The difference between the data collected at the beginning and end of the period do not show any notable increase in value of juice by reason of the greater maturity of the cane. The percentage of fiber in the cane is quite constant. The second period shows the cane at its maximum content of sugar and establishes the fact, important alike from a culture and manufacturing aspect, that October is the month during which the factory should work up to its maximum capacity in that locality. These data, taken in connection with previous experience in Kansas, indicate that the best season for manufacture is from September 15 to November 15. With a factory fully equipped this would give about fifty days of work, and at 250 tons of field cane per day provide for a crop of 12,500 tons of cane, which ought to be raised on 1,000 acres. The folly of planting 2,000 acres for a factory of less than half the capacity mentioned is at once apparent. It is far better for the farmer to plant less breadth and secure a better crop, than to plant a greater breadth and sacrifice the quality and quantity of cane per acre. Sorghum cane for sugar making can not be successfully grown in the hap-hazard manner which has so long been in vogue in the maize fields of the country. For a time, at least, on the fertile farms of Kansas careful preparation of the soil, timely planting, and thorough cultivation by plow and hoe will suffice. But the time will soon come with sorghum when, as with

other sugar plants, the problem of fertilization must be studied both in the field and in the experimental plot. Farmers should not, therefore, expect good returns without careful study of the agricultural problems which the proper growing of sorghum presents.

MANUFACTURING OPERATIONS AT MEDICINE LODGE.

The general character of the factory at Medicine Lodge, as in the other cases, will be found in the reports of Messrs. Cook and Spencer.

In the case of this factory it is a matter of congratulation to be able to say that it was located with due regard to the supply of water and that this water was of good quality. Not only was there an abundance of water for all manufacturing purposes, but on account of the failure of the apparatus to remove the exhausted chips successfully and economically a stream of water was used under the battery to carry off the chips as they were dropped from the cells.

The delays incident to the operating of new machinery were not escaped by the Medicine Lodge Company, and the factory, as in the other cases, fell far short of its estimated capacity. One of the chief delays was caused by the failure of the Yaryan multiple effect pan to evaporate the diffusion juices with sufficient rapidity. This failure was due to the coating of the tubes which necessitated frequent cleaning, the whole factory having to be stopped for this purpose. The experience at Medicine Lodge was that of other places in respect of this point and shows beyond doubt the necessity of providing a larger evaporating surface for sorghum juices in proportion to the amount thereof than for either sugar-cane or beets. In fact, the difficulty of keeping the multiple effect pans clean has been so pronounced that it seems a wise thing to advise the erection of this part of the apparatus in duplicate, so that one set of evaporating apparatus can be in use while the other is cleaning. It might be possible to arrange the pumps of the apparatus in such a way that one system of pumping would be sufficient for the duplicate apparatus, and thus the expense of the additional plant would be confined to the direct cost of the evaporating apparatus itself.

The results of the season's work come more nearly showing a profit on manufacture when all legitimate charges are allowed for than in any other factory where the details of manufacture have been reported to this Department; nevertheless when proper allowance is made for interest on investment, wear and tear, taxes and insurance, it is seen that the factory was operated at a loss.

As a result of the delays noted above and of the late date at which the operations were commenced, it was found impossible to work the whole of the crop, only about 1,000 acres of cane having been delivered when the factory was closed. It is but fair to say that if the amount of second sugar obtained should be equal to that claimed in the report just quoted it will show probably a direct profit of a small amount to the factory for the season's work, excluding the charges above noted.

If, however, the whole of the crop could have been worked promptly, it is evident that a very handsome profit would have been realized. This is encouraging to the sorghum-sugar industry and is the most positive evidence of economical success that has yet been obtained.

The mean composition of the canes entering the battery, as obtained from a table of analyses prepared by Mr. Sanborn from the work of himself and Mr. Edson, is as follows:

	Per cent.
Sucrose	10.44
Glucose	2.24
Purity	63.66

With good manufacturing work under favorable conditions, the canes of the above composition should have yielded 100 pounds of first and second sugars per ton. The amount of the first sugar made, according to the report of the 1st of January, per ton of field cane was 54 pounds. On the estimated yield of second sugars the total yield of sugar per ton of field cane was nearly 75 pounds. Allowing for the usual percentage of waste in cleaning the cane, it is seen that the actual yield per ton of clean cane agrees fairly well with the theoretical yield which should be obtained.

It is also encouraging to note that this fair financial success was obtained with cane which was considerably inferior to that employed for manufacture both at Conway Springs and Attica. With more careful culture developing a higher grade of cane it is reasonable to expect hereafter a fair economical success of the work at Medicine Lodge.

CULTURE EXPERIMENTS AT MEDICINE LODGE.

The miscellaneous analyses of small samples of cane and single canes received at the factory at Medicine Lodge show the same wide variation in the percentage of sucrose that has always been observed in similar experiments elsewhere. These miscellaneous analyses have been collected by Mr. Sanborn into one large table beginning with analyses on the 21st of August. Even at this early date the Early Amber cane at Medicine Lodge showed a high percentage of sucrose and a high purity. This high percentage of sucrose was increased, however, toward the latter part of this month, as will be seen by the numbers indicating the composition of the single canes or small samples of cane during the whole month. This gratifying showing from the Amber cane is particularly noticed, because in some other localities, as indicated in other parts of this report, the Amber cane has been discredited as a sugar-producing plant. It is easy to see from the analyses that had the factory been ready for work at the time mentioned large quantities of sugar could have been made. At the commencement of the analyses of other varieties on the 1st of September, it is seen that the content of sugar was very much lower, the Early Amber variety being uniformly better than the other varieties at that season. Among other varieties tested were those grown from seeds sent by the

Department from the experiment station at Sterling, and which were planted upon sod and without the proper conditions for successful experimental culture. During September, also, the Early Amber varieties continued to show, in general, the highest percentage of available sugar, although during the latter part of the month there was marked improvement in other varieties in their sugar content. Especially was this true of some of the analyses of Early Orange, which began to show up well after the middle of September. During the latter part of September and in October many samples of Early Orange showed good results, but mixed in with these are many others of Orange and other varieties showing a very poor content of sucrose. The percentage of sugar, however, in the Early Orange and some other varieties kept up well even to the end of the season, analyses as late as the 14th of November showing a content of 12.10 per cent. of sucrose, and a purity of 76.13 in samples of Early Orange cane. In this same table, also, Mr. Sanborn has collected analyses of samples of beets grown at Medicine Lodge which will be of interest by way of comparison with analyses of the sorghum juices.

In order to secure the latest information from the factories in Kansas, the Secretary authorized Mr. W. W. Cook to make a final tour of inspection in accordance with the following instructions:

DECEMBER 16, 1889.

DEAR SIR: I have had the Secretary commission you to serve for one additional month for the purpose of securing some further information for our report, and which you will proceed to obtain in accordance with the following instructions:

You will visit each of the factories having received Government aid during the past year and obtain from the proper authorities the following information:

(1) The number of tons of cane purchased and whether this cane was topped before or after purchase.

(2) The total number of tons of cleaned cane chips used in manufacture. If it be claimed in connection with these two items that a part of the cane was worked for molasses only, you will obtain the total number of tons and the respective amounts claimed to have been worked for molasses and sugar.

(3) The number of pounds of first sugar made and the number of pounds of second sugar made and the number of gallons of molasses obtained.

(4) The quantity of sugar sold and the price obtained therefor, the quantity of molasses made and the price obtained therefor.

(5) The amount of seed produced and the price obtained for any that may have been sold.

In addition to this you are directed to obtain from the stockholders of the various factories, in so far as they can be reached, their statement of the profitableness or unprofitableness of the sorghum sugar industry. You will also see prominent farmers who have raised cane for factories and obtain from them like information. You will put this information into writing and read it over to each of the parties interested before sending it as authoritative.

You are especially also directed to visit the factory at Minneola, where the roasting process was practiced, and, in addition to the information above required, to investigate a rumor which has come to us in the newspapers that fraud was practiced by this company, and if so, the extent and character of this fraud. The factories which you will visit under the above instructions are as follows:

Medicine Lodge, Attica, Conway Springs, Minneola, Meade, Arkalon, Liberal, and

Ness City. You are also authorized to visit the factory at Fort Scott, and, so far as possible, secure the information noted for the above factories.

It is especially desirable that this work be completed and forwarded to me by the middle of January, the time at which your present commission will expire.

I received this morning your report on the beet-sugar experiment at Medicine Lodge, and I am greatly gratified at its favorable termination and desire to thank you for the information sent.

I inclose for your use half a dozen traveling orders, and you will please return those not required.

Respectfully,

H. W. WILEY,
Chemist.

W. W. COOK,
Medicine Lodge, Kans.

In compliance with the above instructions the following reports have been received, comprising the latest information which can be obtained for this bulletin:

NESS CITY, KANS., *January* 2, 1890.

DEAR SIR: In my investigation of the sugar works at this place I find as follows:

Cost of buildings		$11,716.89
Cost of machinery, including the skilled labor in erecting		98,500.00
Cost of common labor in erecting machinery		1,453.30
Quantity cane bought	tons..	749
Total amount paid for cane		$1,498.00
Amount paid for labor while running		$992.00
Total cash paid for fuel during season		$836.00
Quantity without tops worked	tons..	716
Quantity seeds and tops	do...	33
Amount received for seeds and tops, at $2 per ton		$66.00
Total amount molasses made (about)	gals...	7,000
Total amount molasses sold (about 300 gallons)		$63.17
Estimated value molasses on hand (6,700 gallons)		1,005.00

A part of the cane was topped by farmers before hauling in and the tops not delivered, and a part was topped while on the wagons (by the use of hay-knives) after it was hauled to factory, and these tops were sold without thrashing at $2 per ton as given above.

Owing to the excessive dry weather, and cane not maturing, they failed to make any sugar. They only ran about nine days. Their contract with the Kilby Manufacturing Company, of Cleveland, Ohio, was to have the factory ready to run by September 1, but it was not finished until October 1, and owing to this failure on the part of the Kilby Manufacturing Company there is some trouble in making final settlement. According to contract price there is still due the Kilby Manufacturing Company $38,000. They are now negotiating propositions for a compromise, and they think the prospects good that it will be effected. In addition to the above the sugar company is owing about $4,000, a part of it for cane and labor. But they claim they are holding this back in order to help in getting $15,000 in bonds from one township which voted the bonds, but the township officers are refusing to sign the bonds.

There is an unsettled feeling among the farmers regarding raising cane next season; some have plowed in preparation for raising cane, and others are holding off. But if the sugar company pay the bills now due for cane and labor I think the farmers will be satisfied and be ready to try raising another crop. It is the opinion generally that the raising of cane here is a comparatively certain crop. I had a talk with Mr. Calhoun, who has no financial interest in the sugar business, but is president of the

State bank of Ness City. He has been in this country for eleven years, and he says this year is the only failure in the crop of sorghum-cane he has seen since he has been here.

The proprietors of the works here that I have talked with seem quite confident of the financial success of the sorghum-sugar industry, but say it may not sound very well, considering the failure they have made; but that is their conviction. They claim they were well aware they would lose money every day they ran, but they wanted to test the machinery, satisfy the farmers, and try and get the $15,000 township bonds that were being held back.

Yours very truly,

W. W. COOK.

Prof. H. W. WILEY, *Chemist, Department of Agriculture, Washington, D. C.*

MEAD, KANS., *January* 6, 1890.

DEAR SIR: The headquarters of the Southwestern Sugar Company, owning the works at Liberal, Arkalon, and this place, is located at this place, and I have visited the works at the other places and seen some of the farmers and secured as much information as I could, and figures from the book-keeper and president here, giving the figures of the three factories in this report, are as follows:

	Mead.	Arkalon.	Liberal.
Quantity of cane worked.....tons..	384	202	601
Quantity of sugar made (estimated).....pounds..	6,000	4,000	10,000
Quantity of molasses made (estimated).....gallons..	3,750	3,750	7,500
Quantity of seed (estimated).....bushels..	600	400	701
Quantity of clean chips worked (estimated).....tons..	238	126	425
Cost of machinery and erection	$50,524.10	$49,466.75	$50,693.04
Cost of buildings and erection	13,252,71	10,949.49	.....
Cost of buildings	.....	.....	12,916,50
Cash paid for cane	576.79	303.58	902.56
Cost of fuel for season (estimated)	400.00	300.00	600.00
Cost of labor while running	435.00	261.00	609.00
Amount of sugar sold (received)	*75.00	*75.00	†210.00
Value of sugar on hand (estimated)	210.00	140.00	315.00
Value of molasses on hand (estimated)	700.00	700.00	1,500.00

* 1,000 pounds. † 3,000 pounds.

Estimated value of seed, 15 cents per bushel.

The tops were cut off at cutter of mills. The proprietors of these factories were well aware that they would ran at a heavy loss, but ran in order to test and adjust machinery and to satisfy the farmers to some extent. There is some dissatisfaction with the farmers, they claiming there would have been more merchantable cane if they had been ready to commence work sooner. The mills did not commence work until about the 1st of October, and ran about two weeks at Mead and Liberal and about one week at Arkalon. At Liberal and Arkalon they are offering the farmers in payment for the cane not worked one ton of coal and one barrel of molasses for every 15 acres of cane. Most of the farmers are accepting this, but a few are holding off. The company have paid for all labor and cane worked at all these factories, but are still owing on machinery about $20,000 and other bills about $3,000. The farmers are satisfied to go ahead and raise cane another year if they can have some assurance that the factories will be run. The company here is in a rather demoralized condition, but Mr. Heber, who is president of the sugar company and also president of the Mead County Bank, thinks he will succeed in getting it on its feet soon.

Every one in the county connected with the company and outside of it seem to think the sorghum industry is going to be a great success. There was no second sugar made at any of these factories.

You will notice that the sugar sold and estimated value of sugar on hand does not amount to the total made. It is claimed a large amount was carried off in samples.

Yours very truly,

W. W. COOK.

Prof. H. W. WILEY,
Chemist, Washington, D. C.

MEAD, KANS., *January* 7, 1890.

DEAR SIR: I have made as thorough an investigation of the purported fraud practiced by the American Sugar Company, at their works at Minneola, as possible. This company is operating with the Adamson roasting process, and as their headquarters are at this place and the officers and parties that were engaged in working up the bonds are most of them living here, I have done most of my work and investigations at this place. The officers of the American Sugar Company sent to Dodge City and bought two barrels of sugar and mixed into their sirup (by advice, as they claimed, of their sugar-boiler) in order to start it to graining, and it was brought in and mixed during the night-time, for the reason (as they claimed) that they had enemies to their process who would use it against them if it was done publicly and by daylight, and about October 26, in the presence of quite a number who had been invited to be present, this sugar was thrown out, claiming to have been made by their process and from cane grown in that section. A short time previous to the time this sugar was thrown out one Willis G. Emerson, residing at this place, made a contract with the American Sugar Company for certain territory to work, and secure bonds to the amount of $15,000 on each township, in consideration of which the American Sugar Company were to erect a sugar factory of the Adamson roasting process. The contract made with Mr. Emerson was that he should furnish his own assistance and pay all expenses incurred in the work and receive as his compensation a certain per cent. on all bonds he secured. Before entering upon his work, and before the day the sugar was made at Minneola, I am told by good authority (and may have an affidavit to inclose in this to that effect) that Mr. Emerson had said he wanted sugar if they had to haul it to factory. Mr. Emerson employed some six or eight persons to assist him, and armed with this sugar (made at Minneola by the Adamson roasting process), as samples showing what the process would do, started out to work filling township scrip for some imaginary debt and calling elections to take up the scrip by issuing refunding bonds. Everything seemed to be getting along finely. The people out here, where they had failure of crops and times were hard, seemed willing and eager to accept anything that would seem to offer relief. They had succeeded in securing the bonds from four townships in this (Mead) county, and two townships in Ford County, and were calling elections in large numbers of other townships when the illegal manner in which they were obtaining the bonds was beginning to be agitated by some, and some newspaper comments had been made upon it, and in one township the party holding the scrip had been compelled by drawn fire-arms to surrender the scrip, and there being some little quiet talk about the manner in which sugar had been obtained, Mr. Emerson came in and demanded of the officers of the American Sugar Company that they pay to him the amount of money he had expended, claiming it to be $4,200. This they refused to do, and he (Emerson) rushed into print, exposing the manner the sugar was made, claiming he had just found it out and wished to protect the people. It seems to my mind the fact of their intending to vote bonds upon about one hundred different townships, and agreeing to build as many sugar factories is as much evidence of fraud as anything that has been done. I have secured what affidavits and evidence I could and inclose them in this. I do not think there is any question but the American Sugar Company and those working for them have practiced a deception upon the people and

it is a great injury to the sugar industry at large. And it would seem too bad that those trying in good faith to build up the industry should suffer thereby. The bonds issued and delivered as mentioned before, viz, the bonds from four townships, are held by the bank here, and those from two townships are back east. The townships so far have been unable to get them back. Can not say what will be done with them. All further operations were promptly suspended when the matter became known to the public.

Yours very truly,

W. W. COOK.

Prof. H. W. WILEY,
Chemist Department of Agriculture, Washington, D. C.

HUTCHINSON, KANS., *January* 8, 1890.

DEAR SIR: The president and book-keeper of the American Sugar Company have furnished the following figures regarding their factory at Minneola, Kans., to wit:

Cost of machinery		$18,658.00
Cost of buildings		$12,000.00
Cost of erecting machinery and buildings		$4,136.19
Quantity of cane worked	tons	469
Cash paid for cane		$727.99
Cost of fuel for season		$233.16
Cost of labor while running		$1,353.20
Quantity of sugar made (about)	pounds	2,000
Quantity of molasses made (about)	gallons	4,664
Quantity of seed (about)	tons	87
Value molasses on hand (estimated)		$900.00
Value seed (estimated)		$250.00

A very small amount of sugar is on hand; it is claimed it has been carried off in samples.

I go from here to Fort Scott.

Yours very truly,

W. W. COOK.

Prof. H. W. WILEY,
Chemist Department of Agriculture, Washington, D. C.

FORT SCOTT, KANS., *January* 10, 1890.

DEAR SIR: In regard to the sugar factory at this place I find as follows for the season of 1889:

Quantity of cane worked	tons	7,113
Amount paid for cane		$14,226.00
Cost of fuel for season		$1,473.83
Cost of labor for season		$7,834.68
Quantity of sugar made	pounds	358,840
Quantity of molasses made (estimated)	gallons	100,000
Quantity of seeds in tops	tons	675
Estimated value sugar product at 5½ cents		$19,736.20
Estimated value molasses product		$10,000.00
Estimated value seed product		$1,350,00

They have about 800 barrels of sugar on hand, not sold, and they estimate their entire product at 5½ cents per pound, and the molasses at 10 cents per gallon.

They have sold some of the molasses, and it has netted them that amount. They have the seed on hand in the tops, and they estimate it at $2 per ton. The tops were cut off by farmers and brought to factory separate, and after cane was delivered. The factory here commenced work August 28 and made one day's run entirely into sirup, and they ran about sixty days and worked up all the good cane they had. A part of the cane was planted upon the creek bottom, and overflowed two or three times during the summer and cut their crop short. It was a wet, cold, and backward spring, and the cane nearly a month later than usual in maturing.

Mr. J. C. Hart, the chemist and superintendent, is confined to his room with influenza, and I could not see him. Mr. Eli Kearns, the treasurer of the company, who has given his time in active work in the business during the past season, says heretofore he has been somewhat undecided as to the ultimate financial success of the industry, but says now he believes it will get on to its feet and be one of the greatest industries of Kansas, especially if the growing and manufacture of beets can be combined with cane. Mr. C. F. Drake, the president of the company, says he has had confidence in the final success of the business and has still more confidence after the past season's work and experience, but thinks there will be many improvements made in the business.

I have not been able to see any farmers at this place, but it is claimed there is no question about it paying the farmers to raise the cane better than any other crop they can raise.

I find the experiment at Medicine Lodge in beets has caused a great interest over the country. At this place they are thinking of raising beets the coming season. They were asking me about it, and I told them there would be an official report on it from the Department of Agriculture soon.

I go from here to Conway Springs.

Yours very truly,

W. W. Cook.

Prof. H. W. Wiley,

Chemist Department of Agriculture, Washington, D. C.

Conway Springs, Kans., *January* 11, 1890.

Dear Sir: In making up a summary report of the sugar works at this place, for the year 1889, I find as follows:

Value of real estate (estimated)		$10,000.00
Value of sugar works (estimated)		$82,500.00
Quantity of cane worked	tons..	4,596
Amount cane cost		$6,894.00
Cost of labor for season in working		$12,359.00
Cost of fuel for season		$3,259.00
Cost of cooperage (about)		$850.00
Number of men employed night and day		80 to 90
Quantity of first sugar made	pounds..	209,591
Quantity of second sugar made	do....	57,485
Total quantity sugar made	do....	267,076
Total quantity molasses made	gallons..	58,500
Cane planted (estimated)	acres..	800
Value sugar product (estimated)		$14,689.18
Value molasses (estimated)		$5,850.00

At this place the farmers topped the cane and kept the tops, and the sugar company paid $1.50 per ton for the cane without tops. The sugar company are in a

demoralized state. They stopped working sirups into second sugars the first of the year, after working about 25,000 gallons and having about 35,000 gallons not worked. There is due farmers for cane about $7,000, and for labor about $4,300. The latter is secured by indorsing to a trustee the 2 cents per pound as a bounty due from the State.

The Kilby Manufacturing Company, of Cleveland, Ohio, holds the first lien on the sugar factory to the amount of $25,000, and it seems to be the impression that this company will eventually own the works, and are already making some proposals to the farmers to form a stock company and buy the works, offering to give them liberal time in making payments, and it is not altogether improbable that some such arrangements may be consummated. The farmers are willing to raise cane at $1.50 per ton, but must have pretty good guaranty in future that they will get paid for it. I had a talk with H. H. Richards, the president of the sugar company, and have seen no one who seems to be as enthusiastic as he as to the future financial success of the industry. Mr. Osterhouse, the book-keeper and stockholder, says, while the sugar works here has worsted all of them that put any money in it, owing to the bank failing to furnish the money they had promised and bad management, yet, if he had sufficient amount of money, he would engage and invest in the sugar business in preference to any other. Mr. Wilson, who is also connected with these works, also expressed himself as having confidence in the final success of the industry, and all I have met seem to think the same way.

Yours very truly,

W. W. Cook.

Prof. H. W. Wiley,
Chemist Department of Agriculture, Washington, D. C.

Medicine Lodge, Kans., *January* 14, 1890.

Dear Sir: I have just returned from Attica, and have to report upon them the sugar factory at Attica for the season's work of 1889 as follows:

Cost of machinery		$52,747.21
Cost of buildings and erecting machinery		$33,775.74
Quantity of field cane worked	tons	7,082
Amount paid and due for cane		$10,566.76
Amount of cane furnished on stock		$3,597.35
Cost of fuel for season		$3,387.02
Cost of labor while running		$10,555.14
Cost of cooperage		$2,044.74
Cost of incidentals		$845.85
Salaries paid while running		$2,406.17
Lubricating		$370.08
Quantity first sugar made	pounds	256,481
Quantity second sugar made	do	41,000
Total quantity sugar made		297,481
Quantity molasses made (estimated)	gallons	60,000
Sugar sold, 203,000 (amount received)		$11,148.56
Molasses, sold 4,573 gallons (amount received)		$352.44
Value sugar on hand, 91,481 pounds, at 5 cents per pound (estimated)		$4,724.05
Value molasses on hand (estimated)		$5,542.70
Number of men employed day and night		66 to 116

Commenced work August 26, and stopped cutting cane November 12.

At this factory they bought cane with tops on and paid $2 per ton, and 50 cents on each ton was applied as stock. The tops were cut off at cutter and used as fuel. These works, as I wrote you before, went into the hands of a receiver with liabilities

of about $59,000. They estimate there will be about 80,000 pounds more of second sugars when they get the molasses all worked over. They have spent a considerable time in fixing their hot room, and have not worked more than a third of their sirup over.

Mr. J. S. Jobes, president of the Attica State bank, and the receiver of the sugar works, says he is confident of the success of the sugar industry. He says he thinks these conditions will cover it, viz:

Experience in the business, plenty of capital, and first-class business management. I talked with several farmers; they say they are willing to raise the cane at $1.50 per ton if they can get pay for it, as that will pay them better than any other crop they can raise.

I should have stated in the figures giving the cost of buildings and machinery is included the cost of the city water-works, amounting to $8,385.

Yours very truly,

W. W. Cook.

Prof. H. W. Wiley,
Chemist Department of Agriculture, Washington, D. C.

Medicine Lodge, Kans., *January* 15, 1890.

Dear Sir: I herewith submit to you my summary report of the sugar factory at this place for the season of 1889, which is as follows:

Cost of buildings		$18,983.38
Cost of machinery and erection of the same		$73,324.00
Quantity of field cane worked	tons	7,363
Cash paid for cane		$7,536.33
Amount donated in cane		$5,984.28
Amount paid for fuel		$7,539.41
Cost of labor while working		$6,594.46
Cost of salaries while working		$980.00
Entire cost of cooperage		$1,370.67
Incidentials while working		$459.26
Lubricating and oils		$145.00
Number of men employed, including day and night		60
Quantity of first sugar made	pounds	330,251
Quantity of second sugar made to date	do	111,987
Quantity sugar to date	do	442,238
Quantity of molasses for season	gallons	79,380
Quantity of hand-picked selected seed	bushels	1,200
Quantity of second sugars yet to make (estimated)	pounds	60,000
Quantity of common seed thrashed	bushels	8,800
Amount of sugar sold, 313,916 pounds (amount received)		$17,047.17
Amount of sugar on hand, 128,322 pounds (estimated)		$7,057.71
Estimated value molasses, 8 cents per gallon		$6,350.40
Estimated value 1,200 bushels select seed		$1,500.00
Estimated value 8,800 bushels common seed, at 15 cents		$1,320.00

Messrs. Eldred and Hinman, the proprietors of the works here, had the farmers top the cane in the fields and haul it in afterwards, but all of the seed was never delivered. They have coal enough on hand (that is included in the above figures) to work over the balance of the second sugars, and all other labor and expenses are figured up to the present time and they figure the balance of labor and expense in working over the balance of the molasses will be about $450; so in summing up their season's work, and taking inventory of stock and cost and expenses from the time

they commenced working cane until they finished working molasses into second sugars, shows as follows:

Value of sugar sold	$17,047.17	
Value of sugar on hand	7,057.71	
Value of sugar to make	3,300.00	
Value of molasses	6,350.40	
Value of 1,200 bushels select seed	1,500.00	
Value of 8,800 bushels common seed	1,320.00	
Two cents per pound, bounty paid by State	8,004.76	
		$44 580.04
Cash paid for cane	7,536.33	
Amount of cane donated	5,984.28	
Cost of fuel	7,539.41	
Cost of labor while working	6,594.46	
Cost of salaries while working	980.00	
Cost of cooperage	1,370.67	
Incidentals while working	459.00	
Lubricating and oils	145.00	
Estimated cost in working balance sugars	450.00	
		31,059.41
Profit of season's work		13,520.63

This factory did not commence work until September 9, which was over a month after cane was matured, and stopped cutting cane November 11, making sixty-two days, and about one week of that time it was so wet that farmers could not haul cane out of the field and they were subjected to delays in adjusting machinery that would be incident in starting any new works having as much machinery as a sugar factory. Considering these delays, and the fact that nearly all the men were entirely inexperienced and had never worked in a sugar factory before, this company has fully demonstrated that if the conditions necessary to success are complied with the manufacture of sugar in Kansas is going to be a grand success, and more especially when it is taken into consideration (as demonstrated by the recent experiment made at this factory) that beets can be raised and made into sugar successfully as well as sorghum cane, forming a combination that no other country is favored with and lengthening the season of actual work in manufacturing to at least six months in the year.

I would mention the following conditions necessary to exist in order to success:

A location where there is an abundant supply of good water, at least 1,000,000 gallons every twenty-four hours.

The best of machinery, constructed and arranged with a view of economy in labor.

Experienced workmen, plenty of money, and good business management:

A majority of the factories in the State have been unfortunate during the past year (and if a dividend has not been declared I well understand how difficult it is for the public to accept any reasons for it), the causes of which are easily explained and well understood by parties familiar with them, as follows: The cane grown at the five sugar factories located in the western part of the State did not mature sufficiently to make sugar, owing to a scarcity of rain in that section of the State, the oldest inhabitants claiming that it is the first year they have ever known sorghum cane fail to mature, and other factories have had an insufficient supply of water, defective machinery, a limited amount of capital, and poor business management. I think in the future one of the greatest drawbacks to the industry is going to be in parties securing subsidies and undertaking the business without due regard to the conditions necessary to success.

I feel that Messrs. Eldred and Hinman deserve a great deal of credit, for they have worked untiringly and spent their time and money to make the business a success, not only for the benefit of themselves, but for the good of the country at large.

They have kept everything with a system, and are ready and willing to give the public the benefit of any knowledge or experience they may have obtained. There are some improvements, which are minor compared to the entire works, which Messrs. Eldred and Hinman are contemplating making before the commencement of this year's work, and some other improvements they are desirous of making which are of more importance and somewhat expensive, to wit, to enlarge their storage and hot room and supply it with additional tanks so as to reboil the molasses and store it in the hot room preparatory to graining and throw out the sugar at the same time they are making first sugars, thereby saving the additional expense of working over molasses into second sugars after the factory has stopped cutting cane. They also desire to put in bone-black filters to filter the juice, and put in a refinery in a small way to refine their own product; also to put in vats for washing beets, cutter to cut them, and more defecators and appliances for handling the beet juice and utilizing the skimmings and settlings.

I have interviewed Messrs. Eldred and Hinman as to their views regarding the financial success of sugar-making in Kansas, and they claim that it is no longer an experiment, but their work and experience during the last season have fully demonstrated to their minds that if the conditions heretofore mentioned are complied with success is assured. They claim that it requires a large amount of capital to construct and operate, and will be necessary to expend still more in order to secure the best results. They have great confidence in using bone-black filters and refining that they will greatly improve their sugar and make it of an uniform grade and color, and will also improve the quality of the molasses so as to meet a ready sale at more than double the price they are able to obtain now. They feel quite confident they will be able to make 1,500,000 pounds of sorghum sugar alone during the present year, and with the manufacture of beet sugar in connection with sorghum, they say, expect to greatly increase this amount.

I have talked with several of the prominent farmers who raised cane the past year for the sugar factory and they say that even this year the cane paid them much better than any other crop they raised, and they are making calculations on raising both cane and beets the present year.

Col. C. H. Eldred, one of the proprietors of the sugar works, is now feeding about seven hundred head of cattle on grounds adjoining the sugar factory and is mixing one third ground sorghum seed to two thirds corn, and says that he is getting better results than he ever did in feeding corn alone, and if he had a sufficient amount of the sorghum seed he would use it in equal parts of corn. As Mr. Eldred is an experienced feeder of many years, his judgment can be relied upon.

I do not think Congress could make an appropriation with a better prospect of benefiting the people and country at large than to continue aid to this industry, and I do not think it should be done sparingly, but liberally to those who are working in good faith and will use it not only judiciously, but with good judgment for the benefit of the industry and the public good. It may be I am presuming too much in this direction, but I assure you that it is a matter I feel a deep interest in, and if it receives aid and encouragement I confidently believe that within the next few years it will be the leading industry of this section of the country.

In this my last report, and closing my work for the Department of Agriculture, I wish to say my associations with all parties connected with the several sugar factories has been of the most pleasant nature and I have received the most courteous treatment at their hands. And I desire to extend my thanks for the kind treatment and assistance in my work that I have received from the Department of Agriculture. Trusting that I have rendered some assistance to the enterprise, and with best wishes for the future success of the industry, I am

Yours very truly,

W. W. COOK.

Prof. H. W. WILEY,

Chemist Department of Agriculture, Washington, D. C.

SUMMARY OF MANUFACTURING WORK.

A general review of the work of the several factories engaged in sorghum sugar making during the past season is not of an encouraging character. In seven factories the record is total failure. An attempt to locate the causes of these failures has been made in the discussion of the several reports. The only gratification which the Department can derive from a view of these failures is in the fact that they are not wholly chargeable to irremediable defects in the plant producing the sugar, but rather from inattention to the facts demonstrated in our past work and fully set forth in previous reports, especially in Bulletin No. 20. It is scarcely credible that in some of the places where the season's work was attended with failure sites could have been selected and factories built in plain disregard of the absolute conditions of success determined by the Department's work.

Since it is possible that the same errors may be repeated, and the same disasters incurred, it will be well to reproduce the resumé of conditions for success taken from Bulletin 20, pp. 17 *et. seq.*

POINTS TO BE CONSIDERED IN BUILDING A FACTORY.

"It is of the utmost importance, both for the individuals and the industry, that intending investors in the sugar business should carefully consider the problem presented to them in all its forms. Failure is not only a personal calamity, but a public one, in that it deters capital from investment in an industry which, properly pursued, gives promise of a fair interest on the money invested.

"*Soil and climate.*—The importance of soil and climate has already been discussed. In the light of present experience it must be conceded that a soil and climate similar to those of southern central Kansas are best suited to the culture of sorghum for sugar making purposes. Further investigations may show that Texas and Louisiana present equally as favorable conditions, but this yet awaits demonstration. Conditions approximately similar to those mentioned can doubtless be found in Arkansas, Tennessee, North Carolina, and other localities. The expectations which were entertained and positively advocated a few years ago of the establishment of a successful sorghum industry in the great maize fields of the country must now be definitely abandoned. He who would now advise the building of a sorghum sugar factory in northern Illinois, Indiana, Iowa, or Wisconsin, would either betray his ignorance or his obstinacy. A season of manufacture, reasonably certain for sixty days, is an essential condition to success in the manufacture of sorghum sugar. Early frosts falling on cane still immature, or a freezing temperature on ripe cane followed by warm weather, are alike fatal to a favorable issue of the attempt to make sugar. Sober and careful men will not be misled by the claims of the enthusiast, by the making of a few thousand pounds of sugar in Minnesota,

by the graining of whole barrels of molasses in Iowa. Four or five million acres of land will produce all the sugar this country can consume for many years, and these acres should be located where the climatic conditions are most favorable. During the past season sorghum cane matured as far north as Topeka, but in 1886 the cane crop at Fort Scott was ruined by a heavy frost on the 29th of September, and in 1885 a like misfortune happened at Ottawa, Kans., on the 4th of October. These interesting facts show that these points are on the extreme northern limits of safety for sorghum sugar making, and the region of success will be found to the south and west of them.

"Natural fertility of soil must also be considered as well as favorable climate. The sandy pine lands of North Carolina can not hope to compete with the rich prairies of southwestern Kansas and the Indian Territory. Indeed, in my opinion, the last-named locality, should it ever be opened to white settlers, is destined to be the great center of the sorghum sugar industry; nevertheless, those who plant the virgin soils of this great southwestern empire must remember that to always take and never give will tire the most patient soils, and a just return should be annually made to the willing fields. A judicious fertilization, rotation of crops, and rest, will not only preserve the natural fertility of the fields, but give even a richer return in the improved quality of the cane and the greater tonnage secured. Perhaps the most sensible solution of the problem of the disposition of the waste chips will be found in returning them to the soil. These chips have a positive manurial value in the nitrogen they contain, while their merely physical effect on the soil may prove of the highest importance.

"*Water supply.*—The misfortunes which have attended many attempts in the manufacture of sugar by diffusion, by reason of an imperfect or insufficient water supply, are a sufficient warning on this subject to the careful student. Not only should the water supply be abundant and easily accessible, but that portion of it, at least, which is to be used in the battery should be as pure as possible. The presence of carbonate of lime and some other carbonates in water is not injurious, but the evil effects of a large amount of other kinds of mineral matter are shown in the data from Conway Springs. When the supply of water is insufficient it has been customary to use ponds for receiving the waste from the factory, so that it may be used again. This method is applicable if care be taken to prevent organic matters, scums, etc., from entering the water supply. In case this precaution is not taken the operator of the factory may find himself in the condition in which the Department was placed in its first experiments at Ottawa and Fort Scott, in being compelled to use water foul and putrescent. It is scarcely safe to rely upon a well for a supply of water, especially if it has to be sunk to any depth. Where pumping machinery must be placed many feet below the surface, as in the cramped condition which attends its erection in a well, serious difficulties may arise from the machinery getting out of order, and a great

loss of energy may ensue from the necessity of lifting the water to a great height. In all cases where it is possible a running stream of water should be selected for the supply, and the factory should be placed conveniently near its banks. The importance of this matter is emphasized the more when it is considered that the most favorable localities for sugar making, as indicated by the present state of our knowledge, are situated in regions where the water supply is notably deficient. Yet it must be admitted that even in southern and western Kansas it will not be difficult to find localities for the erection of sugar factories where the water supply is certain and abundant. In the light of past experience it is not probable that any further mistakes will be made in this direction. Careful estimates should be made of the quantity of water required, and absolute certainty should be secured of the supply of that amount of water, and even of a much greater amount in cases of emergency. The only safety will be found in some such plan as this.

"*Proximity of cane fields.*—Another point which must be taken into consideration in the location of a factory is the distance which the cane is to be transported. This is a matter which of course the farmers raising the cane are more interested in than the proprietors of the factory, when the cane is grown by contract. With good roads, in a level country, it is easy to draw from 1½ to 2 tons of field-cane at each load. The average price which is paid for such cane at the present time is $2 per ton. It is evident that at a given distance, varying according to the price of teams and labor in each locality, the cost of transportation would equal the total receipts for the cane; in this case the farmer would have nothing left to pay for the raising of the cane and profit. Evidently true economy, from an agricultural point of view, would require the cane to be grown as near the factory as possible. It would be well, indeed, if all the cane could be grown within a radius of 1 mile from the factory. This would give, in round numbers, 2,000 acres tributary to a factory. With an ordinary season this ought to produce 20,000 tons of cane. The lengthening of the radius of this circle by one-half mile would give the greatest distance to be hauled 1½ miles, thus vastly increasing the surface tributary to the central factory. It is true that at the present time farmers are easily found who are willing to draw their cane 4, 5, and even 6 miles, but this condition of affairs can not be continued when the business is fully established and the factories in sharp competition with each other. In case the exhausted chips are to be returned to the soil as fertilizer the importance of a centrally located factory, as described, is doubly emphasized.

"*Fuel.*—A cheap and abundant supply of fuel is not less important than the raw material to be manufactured into sugar. As far as the sorghum-sugar industry is concerned the coal which is used for fuel is transported almost exclusively by rail. In locating a factory, therefore, both for convenience of shipping the product and for receiving a sup-

ply of fuel, it should be placed sufficiently near a railway line to enable it to be connected therewith by a switch. It is better, however, that the switch should be of some considerable length than that the water supply should be remote or the cane in distant fields.

"The problem of burning the exhausted chips has not yet been successfully solved, and I doubt very much whether it will be.* Save the softening which the chips undergo in the process of diffusion the difficulty of expressing the water from them is as great as that of expressing the juice from fresh chips. Thus to dry the chips sufficiently to make them economical for fuel would require a vast expenditure of power, which would hardly be supplied by the increased supply of steam generated by their combustion. Experiments during the seasons 1887–'88 at Magnolia Plantation, Louisiana, showed that an ordinary cane-mill was poorly adapted to the pressure of exhausted cane chips. The feeding of the mill was difficult, and the amount of fuel produced seemed wholly disproportional to the expense of preparing it. It has been proposed to try the process used for extracting the water from beet pulp for the purpose of drying sorghum chips. There is nothing whatever in the experience of the beet-sugar factories to warrant the belief that such a process would render the chips sufficiently dry to burn. Although I would not be considered as discouraging any further attempts in the direction of preparing sorghum chips for fuel, I must be allowed to express the belief that for some time to come coal must be chiefly relied upon.

"If the chips are to be successfully burned in the future we may make up our mind that it will have to be done by previous pressure in mills which in all their appointments shall be as strong and efficient as those which have been in use for expressing the juice from cane. It can not be hoped that these chips will be made sufficiently dry by exposing them to the sun, and in artificial desiccation the amount of fuel required would be almost as great as that used in the evaporation of the original juice. It is claimed that at Wonopringo, in Java, as reported in the New Orleans Item of December 16, 1888, the Fives-Lille Company has succeeded in drying the chips by passing them through two powerful three-roll mills, and that the chips thus dried do not contain more than 55 per cent. of moisture and burn readily in an automatic furnace ininvented by Godillot. If it be assumed that 100 pounds of chips contain 10 pounds of combustible matter, it is seen that nearly 80 pounds of water will have to be expressed therefrom before they are fit for fuel. I am doubtful whether such a process will prove profitable save in countries where fuel is very dear, as it is in Java and Cuba.

"*Cost of factory.*—It is an almost universal experience that the actual cost of a sugar factory is underestimated by those who undertake its erection. Many of the disasters which have attended the manufacture

* Since this was written further experiments are more favorable to the possibility of economically using the chips for fuel.

of sorghum sugar have been due to miscalculation of the cost of the apparatus necessary for the purpose. It is the part of wisdom to avoid mistakes of this kind, and before undertaking the erection of a factory to fully understand the amount of outlay which will be required. The cost of the factory will, of course, vary according to its capacity and the character of the machinery and building erected. In my opinion there is little economy in using cheap machinery, hastily and poorly put together. Success is more likely to be obtained by using the very best machinery which has been devised for sugar-making purposes, and erecting it in a lasting and substantial manner. The economy which is secured in operating such machinery far exceeds that which would be obtained by erecting a cheaper plant. The character of the building must also be taken into consideration; it should be sufficiently large to allow a proper disposition of all parts of the machinery without crowding, and sufficiently strong to afford a proper support for such portions thereof as may rest upon it. Due regard should also be paid to risks of fire, and that portion of the factory especially exposed to such dangers should be made as nearly as possible fire-proof. The plans and specifications for all the machinery should be carefully prepared under the direction of a competent engineer and architect, and the machinery furnished by manufacturing firms whose experience and reputation are a guaranty of the excellence of their work. For a complete factory, capable of working 200 tons per day, the cost may be estimated at $60,000 for a minimum and $100,000 for a maximum, the difference being caused by the elaborateness of the work. This may seem a large sum, but it is highly important that intending investors should know the magnitude of the undertaking which they propose. An estimate which exceeds the actual outlay by $10,000 will be far more satisfactory to all parties concerned than one which falls short of it by the same amount.

"*Technical and chemical control.*—The manufacture of sugar from sorghum is no mysterious process known only to one or two persons, as attempts have been made to establish; nevertheless it must be understood that without experience in the manufacture of sugar the most competent engineer may fail. It is best, therefore, that intending investors understand this beforehand that they may be able to secure some one to take charge of the manufacture of sugar who thoroughly understands the needs of the business and has had some experience in the conduct thereof. Perhaps there are not more than fifteen or twenty such men now in the United States, but their number will be largely increased within a short time. It would seem, therefore, that the number of factories which could be successfully operated in the next year or two is limited, and this fact should be taken into careful consideration by those intending to invest money in the business. An intelligent young man of good education, with quick perceptions and of industrious habits, would be able in one year, working in a sorghum-

sugar factory, to obtain a knowledge which would enable him to take charge of a factory, with some degree of success, on his own responsibility. One object which the Department has had in view in its experiments has been in having them open, not only to public inspection, but to careful technical study, to such persons as chose to make the attempt.

"The importance of chemical control of the manufacturing work is so evident that I need not dwell upon it long. The vagaries of the sorghum plant are so pronounced as to require the careful supervision of the chemist at all times. In localities not far removed differences in the character of the sorghum are most marked, as illustrated by the data obtained at Conway Springs and Douglass, Kans., during the past year. To determine the fitness of the cane for the manufacture of sugar, control the workings of the factory, and find and remove the sources of loss in the sugar-house, are duties which can be committed only to the chemist. For many years, at least, this chemical supervision will be necessary, and its utility will always continue."

There are a few observations which the experience of the past season makes pertinent. First of all, until exhaustive studies of the agricultural conditions can be obtained, it may be taken for granted that factories should not be built in arid regions such as were presented last year by Ness City, Mead, etc. It would be criminal rashness to multiply factories in such localities, and a most reprehensible advocacy of the industry to persuade communities or capitalists to invest in them. It may be, as has already been intimated, that some system of agriculture will be devised which will insure with reasonable certainty a good crop. It is not necessary to the success of the industry that a fine crop should be made every year, but it is necessary that a crop of fair quality be assured. It has been demonstrated that under the conditions obtaining this year, such assurance is impossible in the localities mentioned above. The climatic history of that portion of the State indicates that in a majority of the seasons no better results can be expected than were obtained this year. To represent to an already grievously burdened community that favorable results are certain, and on the basis of such a misrepresentation to induce it to further burden itself with an overwhelming debt is a plan of procedure which should deserve only condemnation from official quarters. In respect of the central southern portion of the State two seasons of valuable experience have shown that a crop of high sugar producing quality can be grown. Furthermore, the climatic history of that portion of the State indicates that as a rule such a crop can be made. Doubtless there will be many seasons of poorer crops, but few or any of total failure. Until the sorghum-sugar industry shall have been more firmly established, it is the part of wisdom to confine it to limits whose conditions are already determined. Any transgression of these limits should be the prerogative of culture experiments alone. In view of these facts it would be well if new ventures in sorghum-sugar making, in so far as Kansas is

concerned, should not be found farther west than Medicine Lodge nor farther north than Wichita. In the case of abundant private capital, words of warning are scarcely necessary. The capitalist, even if the venture miscarry, is not bankrupt. Official reports should be calm, dispassionate, and unbiased. Representing in these matters the Department, I desire to appear neither as an enthusiast nor an alarmist, but I deem it my duty to fully apprise every interested person, not only of the possibilities of success but also of the dangers of defeat. It is my purpose to prevent official reports from being used to promote the erection of sugar factories in impossible places. Success will never come to sorghum from coercing nature with Congressional appropriations and town and county bonds. Wise protective legislation, judicious experiment, and patient investigations will gradually lead the way to success if success is to be obtained. My advice to each community, however, in respect of sugar factories, is to await the investment of private capital. There is danger in every project of essentially a private nature which depends for its inception on the pledge of a local bonded indebtedness. There are already enough factories built to test the possibilities of sorghum. Wait and see what the result will be. It may be further stated that this view of the matter has been reached after careful consideration incited by the reception of numerous letters from various localities in Kansas, asking advice in respect of voting bonds to sorghum-sugar manufactories. There is no question of the fact that success will come, if it come at all, to the sorghum-sugar industry, not through the present multiplication of factories, but by making even one factory thoroughly successful. Not a single town or county bond is needed for this result.

In respect of the water supply, the disasters of the past season speak more eloquently than words. It has been demonstrated that a sufficient water supply can not be had from a well. The factory of Medicine Lodge owes its success chiefly to its inexhaustible supply of water. The sooner the other factories are placed on the banks of streams, which even in the driest seasons furnish surface water, the better. It is possible that in the immediate Arkansas Valley a sufficient number of wells might be secured to supply a factory with water, but in this case even it is much safer to lay a pipe to the river. With our present knowledge it should be well understood that any one proposing to erect a new factory and to take the water supply thereof from a well, represents a thoroughly unreliable plan, and is unworthy of credence or support. Before last season the well, as a water supply, was an improbability; now it is an anachronism. There is water enough in central southern Kansas to supply a hundred sugar factories. There ought not to be money enough in the whole country to build one depending on a well. The man who honestly visits a locality in the interests of a sorghum sugar factory will look for water before he asks for bonds. Have nothing whatever to do with him who asks for bonds first. There is another

point which ought to be considered in voting bonds. A good sugar factory, to give promise of success, will cost fully $100,000. In granting bonded aid assurance should be given that the beneficiaries have also something to invest and that they will invest it. A town granting $20,000 should be certain that the other $80,000 are forthcoming. To throw together a collection of crude and cheap machines, unwisely placed and rudely covered, is a method of sorghum-sugar factory building that has already had ample illustration. The community which becomes a participant in a work of this kind should be protected in some way against such disasters. I would be willing to withdraw my objection to bond voting, could I see a town aiding to the extent of $20,000 in the erection of a factory on an ample stream of water to which are tributary some thousands of acres of excellent cane land in an approved climate, and under the control of men who have carefully studied the whole problem of sugar-making, and who would bring to the work $80,000 of their own money and the best technical and chemical skill that could be obtained.

Two factories have been operated in such a way as to almost pay running expenses. In a general review of their work it can be seen that, with a more perfect adjustment of parts, the balance of the books would have shown a profit. The most discouraging point in connection with such work is the depressing effect it has upon the industry. Men who have worked hard, night and day, spending not only their time and energy, but also their money, and without return, can not be expected to persevere. There are to-day many men bankrupt or nearly so who a few years ago were in prosperous circumstances. These reverses are due to their attempts to make sorghum sugar. The long list of disasters, now extending over many years, can not fail of their effect, and this effect is not confined alone to those who suffered, but their depression naturally extended to others who, in other circumstances, would be ready to embark in the industry.

Many of those who have suffered have been led to go into the business by having represented to them only one side of the problem, or by statements presumably from those properly informed, calculated to deceive and mislead. In other cases the unfortunates have only themselves to blame, inasmuch as they have had access to all the facts and have not made use of their opportunities.

SUMMARY OF CULTURE EXPERIMENTS.

The most instructive fact connected with the culture experiments is revealed by the statement of the results obtained in localities receiving markedly different quantities of sunlight. These differences were also attended by varying quantities of rain. It is, however, apparent that moisture, when not present in excess, is beneficial to the crop, and the

following principles will be easily established by the experience already obtained:

(1) The quantity of moisture being furnished necessary to the proper growth of the cane, the content of sugar, other things being equal, will depend upon the total quantity of sunlight received.

(2) Excess of moisture diminishes the content of sugar both by reason of interfering with the proper nutrition and cultivation of the plant, and by reason of being conditional on numerous cloudy days, diminishing the quantity of light and heat received.

(3) The content of water in mature normal canes is but little influenced by the rain-fall.

(4) A mean summer temperature of 70° Fah. for the three months of June, July, and August gives a minimum of heat necessary to the maturation of the earlier varieties of cane.

(5) South of the mean isotherm of 70° Fah. for the summer months is a broad belt suitable for the growth of sorghum, the most favorable portion of which is the semi-arid region of the southwestern central portion of the United States.

(6) The corresponding arid regions of the country would become suitable to sorghum production, with a minimum amount of irrigation.

(7) On account of the frequent recurrence of very wet seasons in all regions east of the Mississippi River, the commercial success of sorghum, as a sugar-making crop, in those localities is not to be expected.

(8) The cause of a poor yield of sugar in sorghum of high polarization is due to the presence of some form of carbohydrates or other organic body, exercising a higher melassigenic power than invert sugar or any form of levulose and dextrose.

(9) The tendency of selected seeds from rich canes to produce a uniform crop of high polarizing canes is established under favorable thermic and photic conditions.

(10) The possibility of developing, from existing varieties, a permanently improved crop capable of cultivation for manufacturing purposes is fully assured.

(11) The prospects of doing this with two or three of the standard varieties is more promising than dependence on an experimental or fortuitous development of a new variety free from the faults inherent in sorghum.

Important aid which the Department can extend to the sugar industry of the future is in the line of culture experiments and work with new processes of separating the sugar from the molasses, or in other new and untried lines of work which contain any promise of success. In respect of culture experiments, it is also highly important that any aid given by Congress should be provided for early in the season. An appropriation which is often not made until late in the spring and which does not become available until July 1, is of little

Scale: 1 in. = 96 ft. Field 700' × 622'

Early Orange = Plot No. 2.

Early Amber = Plot No. 1.

Link's Hybrid = Plot No. 3.

Kansas Orange = Plot No. 25.

SORGHUM PLOTS.

Face page 51.

value for agricultural work. For this reason the appropriations made for scientific agricultural experiments should be measured by the calendar and not by the fiscal year. I would especially urge that you bring this matter before the agricultural committees of the two houses of Congress, and secure from them suitable recommendations to make the above suggestions effective. Many of the disasters which attended our earlier experiments in the manufacture of sugar were due to the causes above mentioned, and the removal of that source of disaster will doubtless greatly promote the success of our future.

CULTURE EXPERIMENTS AT COLLEGE STATION, MARYLAND.

In harmony with instructions received from you, I made arrangements with Hon. H. E. Alvord, director of the Maryland Agricultural Experiment Station, and Mr. D. M. Nesbit, of College Station, for the growth of many varieties of sorghum. Major Alvord planted 10 acres under this arrangement, and Mr. Nesbit 5.

The land planted by Major Alvord was plotted and numbered according to the plan given in the accompanying diagram.

The composition of the fertilizers employed on the plots indicated by the letters A, B, C, etc., is found in the following table.

The unlettered plots were fertilized with a mixture of the various substances used. The especial object of the lettered plots was to determine the influence of the different fertilizers, and mixtures thereof, on the yield and sugar content of the canes.

Application of fertilizers.

[Capital letters indicate the plot to which the appended fertilizer was applied.]

A—Corn guano.
B—Fine bone.
C—Muriate of potash.
D—Mixture No. 2.
E—Kainite.
F—Ammonite or cotton-seed meal.
G—Ammoniated dissolved bone.
H—Nitrate of soda.
I—No fertilizer.
J—No fertilizer.
K—Thomas-slag.
L—Sulphate of ammonia.
M—Sulphate of potash.
N—Mixture No. 1.
O—Acid phosphate.
P—Mixture No. 3.
Q—Mixture No. 4.
R—Dissolved bone-black.
S—Cotton-seed hull ashes.
T—Mixture No. 5.
U—No fertilizer.
V—No fertilizer.

Basis of application.

	Pounds per acre.
Nitrate of soda (one part)	320
Superphosphate, dissolved bone, and Thomas-slag (one part)	480
Muriated potash and cotton-seed hull ashes (one part)	320
Kainite (one part)	480
Sulphate of potash (one part)	320
Sulphate of ammonia (one part)	320
Cotton-seed meal and ammonite (one part)	320

Mixtures.

(1) Nitrate of soda, one-half part; superphosphate, one part; muriate of potash, one part.
(2) Ammonite or cotton-seed meal, one part; fine bone, one part; kainite, one part.

(3) Nitrate of soda, one-half part; Thomas-slag, one part; kainite, one-half part; muriate of potash, one-half part.
(4) Nitrate of soda, one-half part; sulphate of potash, one-half part; fine bone, one part.
(5) Sulphate of ammonia, one part; sulphate of potash, one part.

Description of samples of fertilizers used at the Maryland stations.

Serial No.	Fertilizers.	Serial No.	Fertilizers.
6377	Fine bone.	6421	Ammonium sulphate.
6378	Corn guano.	6422	Dried blood.
6379	Muriate of potash.	6423	Thomas-slag.
6380	Kainite.	6424	Nitrate of soda.
6381	Ammonite.	6425	Dissolved bone-black.
6382	Acid phosphate.	6426	Sulphate of potash.
6383	Ammoniated dissolved bone.	6427	Cotton-seed hull ash.

Analyses.

Serial No.	Moisture.	Total phosphoric acid.	Soluble phosphoric acid.	Reverted phosphoric acid.	K_2O	Ammonia.
6377	7.44	29.68	.....	.....	.....	4.59
6378	15.78	14.53	.....	.....	.....	2.24
6379	.62	.....	.....	.....	49.97	.....
6380	9.58	.....	.....	.....	12.37	.....
6381	8.26	4.62	.....	.....	.....	15.12
6382	11.78	20.30	11.44	7.00	.....	.44
6383	10.67	18.69	6.73	8.09	.....	.....
6421	.....	.....	.....	.....	.....	24.45
6422	.....	.....	.....	.....	.....	14.90
6423	.22	19.59	.....	.....	.....	.....
6424	.....	.....	.....	.....	.....	18.05
6425	18.31	16.42	15.34	.74	.....	.82
6426	12.72	.....	.....	.....	27.50	.....
6427	5.96	8.67	.....	.....	25.45	.....

The character of the field-work performed is fully set forth in the following report:

JANUARY 31, 1890.

DEAR SIR: I have the honor to submit the following report upon the essential facts connected with the cultivation, on the farm of this station, during the year 1889, of 10 acres of sorghum, in accordance with a contract made with the U. S. Department of Agriculture, with the terms of which you are familiar, and under your instructions and supervision.

The land, laid off in accordance with a plot furnished by you, had been irregularly and poorly cultivated prior to 1888, and was in low condition. In 1888 it brought a light crop of oats and was seeded to clover. The clover was badly winter-killed (1888–'89), and very little was left growing on the 10-acre square when assigned to the sorghum last April, except a strip a few rods wide across the north side of the field; there a very good clover lay was turned under.

The land was plowed at intervals in April and May, as the season and the condition of the soil permitted, but there were 14 rainy days in April, 20 in May, and 15 in June—24½ inches of rain-fall on this field in these three months—so that work was continually interrupted. Most of the time a team could not cross the field, and progress was very slow.

The planting, which it was intended to do the first half of May, could not be begun till the 18th of June, and was not finished till the 24th. The land was well prepared for a seed-bed before the planting, and the fertilizers applied as described later. After planting, heavy rains came, greatly impeding vegetation and necessitating con-

tinuous hand labor, breaking the surface crust and nursing the young plants as they appeared, in order to secure any sort of a "stand."

The Early Orange, Early Amber, Link's Hybrid, and Kansas Orange were first planted on the four half-acre plots, 1, 2, 3, and 25, in the middle of the field, and "the pedigree seed" in the north section, of about 4 acres, next. These seeds or varieties were nearly all up and in sight by the time the last planting was finished, or on 25th of June.

As already stated, the germination was generally good, but vegetation and early growth exceedingly slow, under the most unfavorable conditions.

The commercial fertilizers used were sent here partly from Washington, by your order, and partly from Baltimore, upon my order, given by your direction and subsequently approved by you.

Samples of all the fertilizers were taken and sent to you, and I have a transcript, kindly furnished by you, of their analyses.

My instructions were to apply fertilizers alike, and at my discretion, to the whole north section of the field, or the four acres assigned to the pedigreed seed. I regarded a complete fertilizer or general mixture as best suited to this purpose and accordingly made three mixtures, of nitrogenous, phosphatic, and potassic materials, respectively, and as follows:

For 4 acres mixed three lots manures, viz:

Lot A:*	Pounds.
Ammonite	300
Dried blood	300
Sulphate ammonia	300
Total	900
Lot B:	
Fine bone	368
Dissolved bone-black	456
Thomas slag meal	100
Ammoniated dissolved bone	456
Acid phosphate	510
Total	1,890
Lot C:	
Muriate potash	360
Sulphate potash	360
Kainite	240
Cotton-seed hull ashes	400
Total	1,360
Aggregate	4,150

These three lots, separately well mixed, were separately applied by being evenly and lightly drilled into the surface soil, with a grain-drill, before the planting. The application was made both ways on the field and very uniformly.

Subsequently, on these 4 acres, after plants had well started, three applications of nitrate of soda were made at intervals of about three weeks, and at the rate of 50 pounds per acre, each time, or 600 pounds of nitrate of soda in all. This made a total of 1,500 pounds of nitrogenous manures, on the 4 acres during the season besides what was contained in the lot B.

The central and southern sections of the field, being together just about 6 acres, were divided, as per diagram on file ("A"), across the field, east and west, into four large half-acre plots, (1, 2, 3 and 25), and five rows of eleven small plots each. This

* See subsequent note as to nitrate of soda.

grand division was then laid off into twenty-two strips or plots for different fertilizers, these running from south to north, *i. e.*, from southern boundary of field to northern boundary of plot 1 (Early Orange). And these twenty-two special-fertilizer subdivisions were designated by letters A to V inclusive, beginning at east end, or southeast corner of field.

Each of these plots or subdivisions crossing or including several plots, was called three-tenths of an acre, but more accurately contained .275 of an acre. Fertilizers were applied to these with grain-drill run south to north before planting, in accordance with a schedule received from your office May 3, 1889. Including three of these subdivisions (J., U., and V.), on which no fertilizers were used, the twenty-two subdivisions or 6 acres received in all, 3,096 pounds of commercial manures, or about 500 pounds per acre. All this was applied, mixed into the soil, just before planting. No other application was made.

I regret to find that in one particular I failed to follow what was a suggestion of yours rather than an order. In a postscript to one of your letters last May, you proposed that the nitrates should be applied early, and the phosphates later. This piece of letter was misplaced and lost sight of till I gathered together all papers for preparing this report. But as the season turned out, I think no harm resulted from this omission. With our continual rains, often very heavy, there would have been great loss had the nitrogenous manures been all applied at once and in advance. While as the plants really did not begin to *feed* till July, it was manifestly inexpedient to delay phosphatic manuring to a later period.

The most interesting and instructive of the field-notes relate to the subdivisions of the long half-acre plots, 1, 2, 3, and 25. These were of same variety of cane, same planting, and subject to the same conditions throughout, on each of these four ploas, except the difference in the fertilizers applied across them, on the twenty-two subdivisions marked A to V inclusive. Although the crop on these plots was, as a whole, late, light, slow, and poor, for the whole season, whenever, on either plot, a subdivision was reached having certain fertilizers, there the crop was good. For examples: (1) B, with fine ground bone, was fair to poor; C, with muriate of potash, E, with kainite, and F, with ammonite, were poor all through; C was very poor. But D, between C and E, receiving mixture No. 2 of ammonite, fine bone, and kainite, was very good all through the season. (2) Similarly, plot L, sulphate ammonia, was very poor; M, sulphate potash, was poor, and O, acid phosphate, was fair to poor. But N, between M and O, receiving mixture No. 1, of nitrate soda, superphosphate, and muriate potash, was good all through. Q, with Mixture No. 4, was good to fair. These remarks apply only to appearance of growing crop.

When the time came for sampling and sending samples to you at the Department, your instructions were carefully observed, and as every sample was marked, and you have the record complete of what you thus received, nothing further on this part of the subject is here introduced. Shipments began September 23, and ceased October 22.

For the sake of carrying as far towards maturity as possible, nearly all the cane not cut in sampling was allowed to stand till after several severe frosts. There was not enough of any one kind or plot to get acreage results and save a sufficient quantity for sampling, unless a *very* small fraction of an acre was used, from which to compute crop product. Such a record was therefore attempted in only a few cases; those gave these results:

Plot No.	Variety.	Rate of cane per acre.
		Lbs.
97	New Orange	25,800
100	Cross of India	19,800
112	Cross of White India	20,400
117	Cross of Amber and Orange	21,600

The following miscellaneous notes are found: First planting, June 18; first plants above ground, June 21.

First varieties to show heads or tassels, viz: August 24, 1889—

No. 34 (*bis.*), Whiting's Early; No. 34 (*ter.*), Whiting's Early; No. 96, Cross of Orange; No. 245, Black-seed Bi-color; No. 246, Red-seed Bi-color.

From a mass of other notes on hand I can find nothing which I think will be of service to you.

But you may discover omissions, and if you do, please call further for what you want and I will furnish it, if possible.

Let me remark before closing that I hardly think it will be expedient to grow so large an area in sorghum and such a variety another season under any circumstances, but I have carefully preserved the boundaries of the plots and should be especially pleased to co-operate with you in growing sorghum again on 5 or 6 acres of the specially-fertilized plots. The sugar question aside, I believe much of interest and value could be derived from continuous cane-growing on these plots with special feeding. We shall be prepared to join you in such work on most favorable terms, and if the season of 1890 *approaches* the normal, we are sure this piece of land will be found specially adapted to sorghum growing.

Very respectfully, yours,

HENRY E. ALVORD.
Director Maryland Agricultural Experiment Station.

Dr. H. W. WILEY,
Chemist, U. S. Department of Agriculture, Washington.

RESULTS ON MR. NESBIT'S FIELD.

INFLUENCE OF FERTILIZERS ON SUGAR CONTENT AND TONNAGE.

The disastrous floods and continuous rains of the season almost destroyed the lettered plots in the Nesbit field; the link's Hybrid variety and many plots of the Kansas and Early Orange being destroyed. The Early Amber was the only variety that furnished a stand on every plot.

The number of days on which rain fell (Washington Station distant 8 miles), and the total precipitation from May 1 to October 1, as taken from the records of the Signal Office, are as follows: Number of days on which rain fell, 71; total precipitation, 30.88 inches.

Number of days on which .01 inch or more of rain fell and amount of rain-fall, in inches, from May 1 to October 1, inclusive, 1889, at Washington City.

Date.	Washington City.	
	No. days on which .01 or more rain fell.	Total rain-fall.
1889.		*Inches.*
May	16	10.69
June	14	5.01
July	15	8.13
August	10	3.07
September	15	3.88
October 1	1	0.10
Total	71	30.88

The results of the field work, with notes thereon, are given in the following letter from Mr. Nesbit:

COLLEGE STATION, MD., *November* 1, 1889.

DEAR SIR: According to contract, I prepared the ground—five acres—selected by you by plowing, subsoiling, harrowing, and rolling. An extraordinary amount of work was bestowed on the land, with the result of a very fine condition of tilth. It was my intention to plant about the 1st of May, but heavy rains following in close succession prevented. The planting was not finished until the 20th of June.

The fertilizers were carefully mixed and applied according to the schedule furnished by you, but a heavy rain and a flood following the application interfered with the fertilizer tests so far as to make them unreliable.

The quantities of seeds furnished of some varieties was insufficient, and some did not germinate freely so that the stand was not perfect in all the plats.

The growing cane was cultivated as thoroughly as the rains would permit, and within sixty days from planting the more forward varieties showed many seed heads.

A storm with strong north wind prevailed September 11, 12, and 13, which beat and broke much of the cane in some plats, while other plants suffered very little.

Samples of cane were shipped to you almost daily during six weeks following September 10. The shipments included at least two samples from each plat, excepting No. 207, and as all were duly marked, I assume that you have a sufficient record of them.

The cane was killed by frost on October 8.

Very respectfully,

D. M. NESBIT.

Dr. H. W. WILEY,
Chemist, Department of Agriculture.

EFFECT OF DIFFERENT FERTILIZERS ON SUGAR CONTENT.

The season was not only a poor one for the maturation of the cane but also for observing the effect of different fertilizers on the sugar content of the canes. In the case of the Early Amber variety it is clearly seen that only the last analyses in October indicate a cane approaching maturity. For purposes of comparative study the earlier analyses are valuable rather for determining the acceleration or retardation of the growth than for actual content of sugar shown.

The three highest percentages of sucrose were obtained in plots M, P, and V. Plot M was fertilized with sulphate of potash, P with mixture No. 3 (nitrate of soda, phosphate slag, kainite, and muriate of potash), and V received no fertilizer whatever.

The three lowest percentages of sugar were obtained in plots E (395), C (550), and M (555). These plots were fertilized with kainite (E), muriate of potash (C), and sulphate of potash (M). The earlier analyses, however, as before stated, are entirely unreliable for purposes of discriminating between the effects of fertilizers.

It is interesting to note that the increase in sucrose, as indicated by the last set of analyses, has been attended with very little decrease in the percentage of reducing sugars, whereas with more favorable season,

as is seen in the results of the Kansas work, the decrease in the percentage of reducing sugars is quite marked and often at the stage of full maturity.

Even had the season been favorable it would not be wise to state any positive results from a single year's trial. It is to be hoped that opportunity will be given to continue similar experiments for a number of years in succession in order that definite conclusions can be reached covering seasons of different climatic conditions.

The seed planted was obtained from the Department Experiment Station at Sterling, Kans., and the best average samples of cane from the plots yielding the seed showed a content of 13.70 per cent. sucrose. (Bulletin No. 20, p. 126.)

In the case of the Early Orange plots the analyses show no appreciable progress in development after the first set of analyses. In fact, in many cases the last analyses show a lower sucrose content than the first. The results show in a most striking manner the disastrous effects of a thoroughly wet season and indicate that successful sugar-making from sorghum must be confined to an area where such seasons are of rare occurrence or never occur at all. The best samples of canes from the plots at Sterling in 1888, from which the seed was taken for Early Orange plots, show the following contents of sucrose:[1]

	Sucrose.
Early Orange seed from—	*Per cent.*
Kansas	12.82
South Carolina	13.62
Arkansas	11.39
Louisiana	12.90

CEDAR FALLS.

ABSTRACT OF THE REPORT OF JOHN BOZARTH.

The crop of Early Amber was grown from seed produced on the farm. The seed which has from time to time been obtained from Kansas has not proved satisfactory. The planting began April 29 and continued one month; 100 acres were planted by Bozarth Bros. and 200 acres by neighboring farmers. As the manufacturing season approached it became evident that the conditions for sugar production were not favorable. The very dry weather greatly injured the crop, no rain having fallen from July 1 till August 8. Several attempts were made to produce sugar, but with negative results. It was found impossible to grain the sirup in the pan, and on standing a long time in the hot room only a light crop of crystals was obtained. In all 140 pounds of crude sugar were made; in addition to this 130 pounds of sugar were made from sirup obtained from Mr. Newton, 20 miles distant.

[1] Bull. No. 20, p. 125.

ABSTRACT OF THE REPORT OF A. E. KNORR.

On my arrival at Cedar Falls, early in September, it was seen that there was no prospect of producing sugar. Owing to the drought everything was parched up. Only three attempts were made at boiling the sirup for sugar. The first run for sugar was made on September 10, from ordinary field cane. The analyses of the juice of this cane were as follows:

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Total solids	14.37	16.27
Sucrose	6.68	7.60
Glucose	6.30	5.93
Purity	47.71	47.80

As might have been expected from the low purity, no granulation was obtained. On September 17 another strike was made on a lot of cane which had been selected from a locality where picked samples of a very high purity had been found. The analyses of three samples of mill juice from this cane are as follows:

	No. 1.	No 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Total solids	16.29	15.73	14.66
Sucrose	9.13	7.11	8.35
Glucose	5.75	6.49	5.10
Purity	56.36	45.29	56.42

To attempt to make sugar from the above material, of course, resulted in failure, although a small crop of crystals was obtained.

The first heavy frost occurred on September 19, and the works were closed September 29.

On October 3, Mr. Knorr, according to instructions, visited Ames, Iowa, to be present at the experiments made with the Jennings process. The cane used had been partly frost-bitten and cut for over a week. The sirup obtained was very dark in color and no attempt was made to produce sugar from it. In spite of the bad results the management of the Iowa station is still confident of securing good results with the Jennings method. The advantage claimed for Mr. Jennings's process is that it is a battery consisting of a single cell, small capital is required to build it, and it can be worked very economically.

RIO GRANDE.

ABSTRACT OF THE REPORT OF H. E. L. HORTON.

Mr. Horton's report was of a very elaborate nature containing, first, a compilation of data obtained during nine year's work at Rio Grande; second, an agricultural study of the season of 1889; third, a record of the run made with the battery on October 12, 1889, and fourth, a brief description of the machinery employed during the season.

The analyses for the season of 1889 commenced on the 21st of September, with samples of Amber cane, which variety continued to be tested until the 23d. The maximum percentage of sucrose in the juice found during this time was 10.05 and the minimum 7.80. From September 23 to October 9, tests were made of the Kansas Orange planted on May 18. This proved to be of very poor quality, the maximum percentage of sucrose being 8.45 and the minimum 3.99. Kansas Orange was again tested from October 10 to 21 with better results than at first, the maximum percentage of sucrose found being 9.14 and the minimum 6.76. The character of the cane improved after the 21st of October, several analyses being made on that day, and the maximum percentage of sucrose found in the juice being 13.23.

Analyses of late orange planted on the 16th of May, were commenced on November 7, and continued until the 13th, showing cane of average poor quality, the maximum percenage of sucrose in the juice being 10.03 and the minimum 4.29. The analyses were continued until the 16th of November, but without showing any improvement in the character of the cane.

Analyses of twenty-cell drawings.

[Run October 12, 1889.]

Cell No.	Temperature, C°.	Brix (corrected).	Sucrose.	Cane in Cell.
		°	*Per cent.*	*Pounds.*
1	21.5	11.72	6.42	307
2	20.0	10.35	5.60	307
3	20.0	11.35	6.13	307
4	23.0	10.05	5.41	307
5	24.0	11.81	6.22	307
6	24.0	10.79	5.64	307
7	22.0	11.59	6.41	307
8	22.0	11.19	5.93	307
9	24.5	13.11	7.22	307
10	24.5	12.81	6.98	307
1	23.0	13.35	7.51	307
2	23.0	12.95	7.13	307
3	24.0	13.61	7.65	307
4	23.5	12.95	7.23	307
5	23.5	13.85	7.85	307
6	.....	.....	.....	307
7	20.0	.....	7.75	307
8	22.0	.....	7.60	307
9	20.0	13.85	7.65	307
10	22.0	13.79	7.65	307

Analyses of ten eleventh-cell drawings.

Cell No.	Temperature, C°.	Brix (corrected).	Sucrose.
		°	*Per cent.*
1	24.0	12.7	6.88
2	23.5	12.9	7.18
3	24.0	12.9	7.33
4	24.0	13.5	7.61
5	19.0	14.1	7.44
6	20.0	14.3	8.12
7	20.0	14.3	8.32
8	20.0	14.3	87.9
9	20.0	14.2	8.03
10	20.0	14.3	8.07

Analyses of ten eleventh-cell drawings—Continued.

	Temperature, C°.	Brix (corrected).	Sucrose.
		°	*Per cent.*
Milled chips	30	14.2	8.86
Diffusion juice	.....	14.2	8.10
Exhausted chips	.....	.....	1.25
Milled cane	21	14.74	9.14
Mean of milled cane and milled chips	.....	14.47	9.00

The first point to call attention to on examining this run is the question: What is to be taken as representing the sucrose number during an experimental run? The chips from shredder and the samples of whole cane do not give agreeing sucrose numbers.

The following observations were made during a run of several hours October 2, 1889:

(A) Seventy-six pounds of carefully hand-stripped cane were milled; when one-half had been run through, a sample of the juice was analyzed, then the remaining half was run through and the two portions of juice mixed and analyzed.

	Brix.	Sucrose.
	°	*Per cent.*
First half	13.3	6.38
First half+second half	13.3	7.31

(B) This sample consisted of two handfuls taken from every basket as packed, twenty in all, well milled and juice analyzed.

	Per cent.
Brix	12.8
Sucrose	5.97

(C) This sample of about 200 pounds represented 1½ tons of cane. A handful was taken from every lagging of the carrier running from the shredder while 1½ tons were worked.

	Per cent.
Brix	13.0
Sucrose	6.63

The sampling and analyses show how difficult it is to obtain a sucrose number which may be said to represent the cane worked during a run.

In the run of October 12, the results of the milled chips and milled cane are given.

Let us look at the dilution from standpoint of total sólids as given by Brix instrument. The milled chips have an average Brix of 14.47, the diffusion juice a Brix of 14.2. How has this been reached?

Two factors suggest themselves in the solution of the question: (A) Evaporization from surface of cells sufficient to make one degree difference in spindle reading; (B) the high temperature dissolving out the inorganic portions of the cane abnormally. Experiments conducted at

Rio Grande, point strongly to the fact that a dilution of 20 per cent., 30 per cent., or even 40 per cent., as in some cases, is not necessary to a good extraction. This question of dilution is one of greatest importance, for here the cost of producing an hundred weight of sugar will be materially lessened by cutting down the water used.

I have collected the following interesting data showing juices obtained at different factories.

Place.	Raw juice.		Diffusion juice.		Remarks.
	Brix.	Sucrose.	Brix.	Sucrose.	
	°	*Per cent.*	°	*Per cent.*	
Mironowka[1] (Russia)	16.41	12.72	9.33	7.32	Ordinary.
Wonopringo[2] (Java)	18.60	16.83	14.70	13.31	
Magnolia[3] (U. S. A.)	16.40	14.10	12.90	11.00	
Mironowka[1] (Russia)	15.61	12.00	11.06	8.72	After Turkiewicz.
Landen[4] (Belgium)	15.70	12.94	11.19	9.27	
Rio Grande,[5] 1888	12.36	6.54	11.83	6.02	
Rio Grande, 1889	14.17	9.00	14.20	8.10	

[1] Deutsche Zucker-Industrie, 12, 29, 950.
[2] Sucrerie Belge, October 15, 1888, No. 4.
[3] U.S. Department Agricultural Bulletin 21, p. 30.
[4] Zeit. Rübenzucker-Industrie, 1889, 375.
[5] New Jersey Agricultural Experiment Station Bulletin 51, page 22, 1888.

In connection with this season's work it will be interesting to see what Rio Grande experiments have already given, and for this purpose Dr. Neale's[1] work may be made use of. His analytical results are as follows:

	Brix.	Sucrose.
	°	*Per cent.*
Fresh cane, shredded	12.36	6.54
Diffusion juice discharged from "eleventh" cell	11.83	6.02
Juice from exhausted chips	.....	0.82

Dr. Neale's extraction in one case was 89.8 per cent.; in this case 85 per cent. In the experimental run of this year (October 12, 1889) 86 per cent. expressed the extraction. In studying these numbers the small sucrose per cent. must bear a prominent part. Had our sucrose been 12 or 13 per cent. our extraction would have been between 90 and 95. This must not be forgotten.[2]

MACHINERY.

Battery.—The battery this season is a new one and has many improvements over the one used in 1887 and 1888. In a run from September 12 to November 12 it never ceased to give satisfaction.

[1] New Jersey Agricultural Experiment Station Bulletin 51, page 22, 1888.

[2] The comparison of a specially controlled experiment with a few cells with the mean working of a battery for a whole season is likely to lead to mistaken ideas of efficiency. The only proper comparison would be between the results obtained for a whole season. This note is added to prevent any misapprehension of the terms "Rio Grande, 1888," and "Rio Grande, 1889."—H. W. W.

The battery is to-day and has been in past only on an experimental, laboratory scale, and the work accomplished with it as such has been of the very highest grade; the run of October 12 shows what it did in ordinary working and under good supervision can repeat this record eighty days out of ninety.

This battery was never designed to supersede the German type. Its inventor and others who have studied it carefully can not claim this for it. It was an attempt to manufacture sugar with simplified machinery and at a figure slightly higher than the recognized minimum working with a large plant. It seems to me that this battery can never compete with the German type when it is desirable to work 200 tons per day, for its capacity seems to be that of a 70-ton house, and its usefulness in a small house can not be questioned; but as a factor in solving the economic production of an indigenous sugar for the United States it has little value.

Studies were instituted on the effect of temperature, dilution, and time of contact of water with fresh chips, and in all cases interesting results were obtained. The work shows, as Turkiewicz has already shown with beets, that the time of contact is the weighty factor in extraction, and not heat and quantity of water used.

The Rio Grande battery is all that could be wished for to carry out the line of investigation begun this summer. The heat was controlled nicely, the quantity of water to within a pound, and the contact by dipping baskets one or more times.

The experiments were preliminary and necessarily not conclusive, but it is to be hoped they may be carried out in the near future.

Cleaning apparatus.—The shredder was the interesting machine in the house, for, to a certain extent, the extraction depends on the size of the chip.

With small chips only 0.5 to 0.8 per cent. sucrose remained in chips, with medium chips 0.9 to 1.25 per cent., and with coarser chips as high as 2.4 per cent. To obtain a chip to allow of 0.5 to 0.8 per cent. remaining in bagasse is no easy matter, for the shredder chokes every ten minutes; but this end may be secured by running chips through a second shredder, in fact, this has been suggested[1] by several, but not until this year has the demand seemed imperative, and now double shredding is called for.

[1] H. A. Hughes, Bull. 20, 36, 1888.

MORRISVILLE.

ABSTRACT OF THE REPORT OF W. MAXWELL.

The report begins with a statement concerning the extent of the estate of the Virginia Diffusion Sugar Company, the character of the soil, the cultivation of the crop, notes on the progress of the growth of the crop, and a description of the factory.

The character of the crop produced is given in a series of tables showing the number of acres in each plot, the variety of cane planted, the date of planting, date of sampling, and the composition of the juices. In general the character of the juice shows the cane grown on the plantation of the company was poor. Only one sample of the cane produced on the company's plantation showed 10 per cent. of sugar in the juice; this sample was Link's Hybrid, planted May 27, and analyzed on October 16.

The mean results obtained from the different varieties are given in the following table:

Averages of varieties.

No.	Variety.	Acres.	Brix.°	Sucrose.	Glucose.	Purity.
				Per cent.	*Per cent.*	
1	Early Amber	53.0	12.4	5.5	2.4	43.3
2	White African	6.0	15.6	9.3	2.8	59.5
3	Early Orange	42.5	14.9	7.4	2.2	49.0
4	Late Orange	17.0	15.4	8.4	2.2	54.4
5	Improved Orange	28.0	16.4	7.9	3.6	49.3
6	Link's Hybrid	4.5	16.4	10.1	4.6	62.0
		151.0	15.1	8.1	3.0	52.9

Samples of cane grown by neighboring farmers showed uniformly better results than were obtained on the estate of the company. The mean results obtained from the various sources above mentioned are given in the following table:

No.	Name.	Variety.	Soil.	Brix.°	Sucrose.	Purity.
					Per cent	
1	W. Anderson	Early Amber	Sandy loam	13.4	6.7	49
2	Mrs. Edwards (*a*)	do	Black loam	16.4	10.6	64
3	Mrs. Edwards (*b*)	Early Orange	do	15.2	8.2	54
4	Mrs. Zimmons	Early Amber	Light gravel	16.3	10.4	64
5	Mr. Brown	do	Sandy loam	17.1	10.8	63
6	Mr. Crop	do	Red gravel	18.2	12.0	66
7	W. Jones	do	Light sand	15.7	11.5	73
8	R. Munroe (*a*)	do	do	18.0	11.6	64
9	R. Munroe (*b*)	do	Dark loam	16.4	9.9	60
10	Mr. Crittenden	do	Red gravel	14.4	8.2	58
			Averages	16.1	9.9	61.5

NOTE.—All these plots were seeded during the first week in May and the canes were samples from September 26 to October 7.

The working of the battery and apparatus in general was of the poorest quality, the inference being drawn that a well appointed mill would have expressed the same quantity of juice as was obtained by

the diffusion battery. From the agricultural and from the milling stand-point the sugar season of the Virginia Diffusion Sugar Company's plantation was not a success. If a remunerative crop had been produced the mill was not in order to work it, and if the mill had been ready there was no crop to be worked.

KENNER.

ABSTRACT OF THE REPORT OF DR. W. C. STUBBS.

Four plots of over 2 acres each were devoted to the culture of those varieties of sorghum which past experience had demonstrated to be the best for sugar-making. Experiments were also carried on at the State experiment station at Baton Rouge and at Calhoun and on the estate of Mr. F. L. Maxwell in Madison Parish. The results of the attempts to make sugar in the sugar-house were rather disappointing; although considerable quantities of sugar were made it was found almost impossible to dry it in the centrifugals, and the sugar obtained was generally of a low grade. Full data of the sugar-house work are given; also of the analyses of the samples grown at the various experiment stations.

The result of the work is summed up in the following review of results:

REVIEW OF RESULTS.

The sorghum grown at Kenner was of an inferior character; that grown at each of the other stations and at Mr. Maxwell's very fine.

The soils of each of these places vary greatly. At Kenner the soil is a black, heavy, tenacious clay, hard to cultivate and harder still to drain, susceptible of injury from extreme drought or excessive rain-fall. Small seed if not too deeply planted germinate quickly in it. At Baton Rouge the brown loam of the bluff formation prevails; a soil which withstands drought well, but can not endure excessive rain-fall. Small seed are with difficulty germinated, due to the soil puddling and forming an impervious crust after every shower. It works with ease, but it is difficult to drain. At Calhoun there exist the sandy and loamy tertiary soils, easily worked and drained; a soil whose physical properties are good and which needs only proper fertilization to make excellent crops in propitious seasons.

At Mr. Maxwell's we have the typical alluvial soil of the upper Mississippi bottoms; a sandy soil easily worked and drained and of great fertility. These four soils well represent all the soils of the State, save the red lands of Red River bottoms and the light prairie fields of southwestern Louisiana.

The season at each of these places varied greatly during the period of the growth of sorghum. At Kenner a prolonged drought following a heavy rain-fall of April 13 greatly injured the sorghum, making it small and spindling. When the rains began on last of June it produced

suckers, greatly to the detriment of the cane. The cane-borer also attacked the sorghum at Kenner and did it considerable damage.

The same drought prevailed at Baton Rouge, but the seed planted in April did not germinate till June, and hence the young plants were not stunted as at Kenner. No worms or suckers interfered.

At Calhoun most propitious seasons prevailed and the canes were fair in quantity and quality.

At Mr. Maxwell's fine seasons prevailed in the early growth of the cane, but near maturity a prolonged drought was encountered which doubtless injured the cane.

In reviewing the agricultural results, it may safely be asserted that dry well-drained loamy soils are best adapted for sorghum, and that showers at regular intervals favor a large sugar content as well as tonnage. Neither droughts nor excessive rain-falls are favorable to a full development of this plant.

Another feature worthy of note: Only certain varieties of sorghum have given good results anywhere. Link's hybrid, originated by Mr. Ephraim Link, of Greenville, Tenn., seems to have succeeded best on a large scale than any other variety. Of the 100 varieties tested this year for the first time only a very few are worthy of further trial.

The sugar-house results were disappointing. In every instance difficulty was experienced in graining in the pan. Only by the addition of crystallized sugar, or by the withdrawal for some time of heat, could graining be started. Even at a temperature of 120° Fahr., with a vacuum of 26 to 28 inches, no grain could be formed. Does our sorghum contain more dextrine and soluble starches than that raised in Kansas, or did we diffuse at too high a temperature? Our records show temperatures ranging from 40° to 80° C. in our discharging-tanks, and yet no perceptible difference in the sirups. Samples of all the molasses have been kept to further study their compositions.

Our greatest difficulty was in purging our massecuite, a great surprise to all. After running the centrifugal sometime it was found on examination that a layer of sugar adhered to the sieve, upon which rested a layer of molasses, and this in turn was covered by a layer of white foam, giving the appearance while the centrifugal was in motion of a beautiful white sugar. After stopping the centrifugal these layers had to be broken down and mixed with a little water and centrifugalled. In this way a good sugar was obtained, but only at the expense of time, patience, and considerable loss of sugar.

CONWAY SPRINGS.

ABSTRACT OF REPORT OF E. A. V. SCHWEINITZ.

The machinery was not tested until August 25, although this might have been done several weeks before; but, for some inexplicable reason, the work was allowed to drag, with, of course, detriment to the business. A difficulty was met with at the beginning which it took several days'

time to remedy. The drag which furnished the cane to the large cutter was not properly placed, and the knives of the cutter were too broad, causing the cane to be forced back at each stroke. It was necessary, therefore, to attach a forced feed to the cutter. This delay was unfortunate, and caused considerable dissatisfaction.

Last year the mill depended for its water supply upon a deep well which was by no means sufficient. In addition, the well pumps gave a great deal of trouble and caused considerable loss of time. Through some unpardonable oversight this defective piece of machinery had never been touched since last season, and work had scarcely been started before the troubles of last year were repeated. With the enlarged capacity of the house the pipe line to the creek did not give sufficient water, and it was necessary to rely upon the well for water for condensing purposes. Instead of remedying this defect at once several weeks' time were wasted, the work in the mean time lagging, as it was necessary to run first one part of the house and then wait till the other had caught up. Finally, a pond was made near the mill, and the waste water collected and used over again for condensing purposes.

It was the intention of the company to clarify the juice by adding lime, and allowing the limed juice to be brought to a boil in a continuous flow skimming-pan. The pan provided for this purpose was deficient in capacity, and only a very poor defection was obtained. The company was very fortunate, therefore, in securing from the Douglas Sugar Works the loan of five clarifiers, as well as several pumps, and forty sugar wagons. Delay resulted in placing these, but without them little work could have been accomplished. Contrary again to better advice, I understand the engine relied upon for working the centrifugals was insufficient, and the house had to be shut down until a new engine could be purchased and placed.

All of these delays were caused by defects patent from the beginning, and which past experience should have induced the company to provide against. The greater portion of the month of September was consumed in this way, and only about 1,500 tons of cane cut, which should be only a week's work. Very valuable time was thus lost, at great expense.

These troubles seemed to have induced a sort of demoralization generally, and while, during the month of October, work was somewhat more steady, there were many delays caused by broken drags, elevators and pumps; many accidents, the result of gross carelessness, others, perhaps unavoidable.

The double effect caused some delays by the tubes becoming coated with scales, necessitating the removal of the heads of the pans and the scraping of the tubes. In the hands of an intelligent workman the loosening of this scale, with a strong solution of caustic soda, and its subsequent removal by washing the tubes with dilute acid, should have been sufficient.

The exhausted chips were removed from the batteries by means of carts and dumped on the adjacent prairie. This is certainly a very sure way of disposing of a troublesome by-product, but a rather expensive one. Four two-horse carts, with drivers, and six additional men, were employed for this work per twenty-four hours, at an expense of about $19. The work should have been done with three or four men less, but even then the method is too expensive. The chips furnished by the shedders the early part of the season were very fine, and in excellent condition for diffusion. Later, the knives became badly gapped from bolts and pieces of iron which found their way to the shredders, and little attention was paid to grinding and setting the knives properly. Hence, with a very large dilution, only a moderate extraction was secured. The new battery gave better results than the old. This was due partly to the shape of the cells of the new battery, narrowing toward the top, with small top door, but chiefly to the larger juice pipes, a better circulation being thereby secured. A number of the yokes to the top doors of the cells were broken, causing some delay. This was due to a fault in the casting. The only advantage gained by having the two batteries was that work could be continued with the one when the other was stopped. It would be far better to have a battery with an extra pipe line, which would permit of any cell being cut out of the circuit when necessary. A saving of labor, fuel, and water is thereby secured, as well as a proportionately smaller dilution, and just as much work could be accomplished.

To sum up in general, we may say that the heavy machinery was entirely adequate and suitable for the work, and that the delays and troubles should not be charged to this, but rather to carelessness and inexperience.

In the early part of the season but little inversion of sucrose was noted in the battery. Later, this increased, and it was deemed advisable to add sufficient lime to the chips in the battery to correct this. Skimmings and settlings were returned to the battery. The juice was limed to neutrality, or as nearly so as possible, and a good clarification secured; still, some inversion was noted between the clarified juices and semi-sirups. This was due chiefly to the manner in which the juice was handled, as for a long time the management pursued a method of allowing the juice to stand and "settle" before evaporation. This was in every respect a suicidal policy, as the juice became cold and sour, and just so much additional fuel was necessary to evaporate it, not to mention the resulting inversion. After this practice had been abandoned, on such days as I was able to see that a strictly neutral clarification was secured, no inversion was noted in the double effect Yaryan.

The diffusion juices showed the presence of large amounts of starchy substances which should be removed by some method of clarification.

The purity of the sirups was fair and the sirups were grained without trouble in the vacuum-pan. The sugar was boiled to a very fine grain,

This fact, as well as the inexperience of the workmen, and the little attention paid to keeping the hot room at a proper temperature, caused the work with the centrifugals to be slow. The sugar also was heavily washed, and a great deal of the fine grain found its way through the screens of the centrifugals. This accounts for the richness of the first molasses, as well as the rather small yield in first sugars. A screw conveyor and elevator buckets should have been provided to remove the sugar from the centrifugals to the sugar room, instead of the boxes used, which necessitated a large amount of hand labor and waste. In several other instances expensive hand labor was relied upon, where an extra wheel or belt would have answered the purpose. One great source of loss was due to the leaks in the joints of the main steam-line, and to the fact that the steam-pipes were not wrapped. The exhaust steam also was not utilized to the extent that it might have been.

The majority of the workmen were inexperienced, and did not appreciate the importance of their particular tasks. There was a very evident lack of harmony between men and managers, and not the firm control and system which is absolutely necessary for the success of any business, especially where the season is a short one, as is the case with sorghum sugar.

The Orange cane was at its best, as last year, about the middle of October, after a light frost sufficient to kill the leaves. The richness of the cane last year was attributed partly to the dryness of the season. This season was one of the largest rain-fall known in Kansas, and yet the average per cent. of sucrose was 11.98 per cent. and glucose 1.78 per cent., and Brix 18.33 per cent.; while for 1888, the average Brix was 19.39 per cent., sucrose 12.42 per cent., and glucose 2.61; or a glucose ratio of 1 : 6.73 in 1889, against a ratio of 1 : 4.76 sucrose in 1888.

This is very interesting and important, especially when the almost exactly opposite character of the two seasons is considered. The seed from last year's crop had been carefully hand-picked and thrashed from the richest plots of last year, and from this source Medicine Lodge and Attica works obtained most of their seed. For this reason, we insert here for purposes of comparison means of Tables I and II from last year's report (Bulletin 20, pp. 83 and 85):

Means.	Solids (Brix).	Sucrose.	Glucose.	Purity.
	Per cent.	*Per cent.*	*Per cent.*	
Table I.....	18.35	12.14	2.35	65.78
Table II.....	19.39	12.42	2.61	63.84

Table I.—Juices from single canes.
Table II.—Juices from chips entering battery.

In this connection it is especially interesting to note the results obtained from Amber cane. The seed was selected from a plot which last year showed a Brix per cent. of 18.81, sucrose 14.09, and glucose 1.26,

Very matured Amber grown upon sod land from this seed showed Brix 17.93 and sucrose 13.10; and upon plowed land Brix 18.28, sucrose 13.20 per cent., and glucose 1.29 per cent. In all cases there was a decrease in total solids as compared with last year and there was a corresponding increase in the purity of the juices. We noted again this year, as well as last, that while the Amber cane deteriorated rapidly if left lying any length of time after being cut, the Orange after it had attained its maximum was fairly stable. Again, several hard freezes and thaws did not materially injure the cane, as can be seen from analyses *a*, *b*, *c*, *d*, and *e*, Table I.

The factory was forced to stop cutting, for reasons which will be mentioned later on, the 8th of November. About 600 acres of cane of excellent quality were left standing in the field, so that on this score the mill might have run until the 1st of January, as from reports I have learned that the weather has been excellent in every way. About November 4 there was a light fall of snow, but as already mentioned without danger to the cane.

A number of varieties of seed were sent out by the Department to be planted for experimental plots. The ground upon which it was planted was a very wet piece of sod land, consequently a great deal of the seed did not mature, and as the plots had not been properly separated or attended to, it was deemed best to condemn the whole.

The total number of day's actual work, counting each day at twenty-two hours, was forty-five; that is, the work should have been done in that length of time if the mill had run fairly smoothly.

The expense for labor and coal was enormous, and might have been greatly reduced with proper care. In summing up the results, then, of this season's work, it is but fair to mention that the expense for labor and coal would scarcely have been a cent more if the mill had run steadily and done four times the work than it was with but little work.

In a trial run, beginning on the 26th of October and continuing until the 2d of November, the following data were obtained:

	Sample No.	Brix (corrected) at 17°.5 C.	Sucrose.	Glucose.	Purity.	Glucose to 100 parts sucrose.
			Per cent.	*Per cent.*		
Chip juices	824	18.29	12.81	1.13	70.03	8.86
Diffusion juices	826	10.00	6.87	.74	68.70	10.80
Mill juices from exhausted chips	813	2.28	1.01	.....	41.84	.....
Clarified juices	827	10.34	7.13	.86	68.95	12.06
Semi-sirup	820	44.56	32.37	3.83	72.64	11.83
First massecuite	.....	89.81	65.60	8.34	.....	12.69
Molasses	.....	78.29	48.40	10.64	61.82	21.98
Second massecuite[1]	.....	88.70	52.10	12.60	.....	24.18
Second molasses[1]	.....	78.10	40.00	13.44	51.21	33.60

[1] From first molasses of trial run.

The mean percentage of fiber, as determined in the chips, during the season was 11.49. Twenty-four determinations were made, extending

over the entire season, from September 5 to November 7. From August 29 to October 3, twenty-six analyses of cane chips, representing the mean composition of the chips entering both batteries, were made. The mean results obtained were as follows:

	Total solids.	Sucrose.	Glucose.	Purity.
	Per cent.	*Per cent.*	*Per cent.*	
Means	18.10	11.39	2.20	62.92
Highest	21.07	12.98	4.02	.....
Lowest	16.86	8.97	.91	.....

Separate analyses were made of the chips entering the two batteries after August 4, with the following results (the results of eighteen analyses, representing the material entering the old battery from August 4 to November 8):

	Total solids.	Sucrose.	Glucose.	Purity.
	Per cent.	*Per cent.*	*Per cent.*	
Means	18.53	12.27	1.38	66.29
Highest	20.40	14.60	3.15	.....
Lowest	16.23	9.00	.54	.....

In the new battery during the same period seventeen samples were analyzed, with the following results:

	Total solids.	Sucrose.	Glucose.	Purity.
	Per cent.	*Per cent.*	*Per cent.*	
Means	18.36	12.28	1.52	66.89
Highest	20.40	13.65	3.65	.....
Lowest	15.98	10.00	.90	.....

The means for the whole season of all the analyses made of the fresh chips are as follows:

	Per cent.
Total solids	18.33
Sucrose	11.68
Glucose	1.70

The data obtained in the analyses of the diffusion juices from the old battery from August 29 to November 2, including 38 analyses, are as follows:

	Total solids.	Sucrose.	Glucose.	Purity.
	Per cent.	*Per cent.*	*Per cent.*	
Means	9.81	6.09	1.04	62.08
Highest	12.35	9.06	1.87	73.36
Lowest	8.27	5.00	.52	49.42

For the new battery the data follow. Thirty-eight analyses were made from August 28 to November 8.

	Total solids.	Sucrose.	Glucose.	Purity.
	Per cent.	*Per cent.*	*Per cent.*	
Means	9.99	6.50	1.03	65.06
Highest	12.00	8.20	2.38	75.26
Lowest	8.38	5.25	.52	51.02

The analyses of waste chips from the old battery for the entire season gave the following data. Total number of analyses made, 54.

	Total solids.	Sucrose.
	Per cent.	*Per cent.*
Means	2.27	1.13
Highest	5.88	2.40
Lowest	1.11	.25

In the new battery the numbers follow. Number of analyses, 63.

	Total solids.	Sucrose.
	Per cent.	*Per cent.*
Means	2.16	.89
Highest	3.58	1.98
Lowest	1.02	.19

Analyses of the clarified juices for the entire season from both batteries gave the following data. Number of analyses, 47.

	Total solids.	Sucrose.	Glucose.	Purity.
	Per cent.	*Per cent*	*Per cent*	
Means	10.25	6.66	1.05	64.97
Highest	12.28	8.20	2.07	73.23
Lowest	8.74	5.00	.45	50.36

Analyses of the sirups for the entire season gave the following data. Total number of analyses, 45.

	Total solids.	Sucrose.	Glucose.	Purity.
	Per cent	*Per cent.*	*Per cent.*	
Means	44.16	29.18	5.19	66.08
Highest	55.46	40.37	9.73	84.24
Lowest	34.82	19.38	3.18	54.11

Analyses of the first massecuites for the entire season gave the following data. Total number of analyses, 19.

	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
Means	90.27	57.86	12.23
Highest	93.34	66.60	23.92
Lowest	84.68	50.20	8.38

The analyses made of first and second sugars follow:

POLARIZATION OF FIRST SUGARS.

Date.	Sucrose.
	Per cent.
Sept. 23	95.8
Sept. 23	97.6
Oct. 7	97.0
Oct. 7	97.0
Oct. 7	94.0
Oct. 22	94.4
Oct. 22	96.0
Oct. 29	96.8
Nov. 4	96.8
Nov. 11	95.2

POLARIZATION OF SECOND SUGARS.

Date.	Sucrose.
	Per cent.
Nov. 11	[1] 91.6
Nov. 11	[2] 94.4
Nov. 15	[1] 88.0

[1] Raw sugar. [2] Washed sugar.

ATTICA.

ABSTRACT OF REPORT OF OMA CARR.

On the opening of the manufacturing season, on the 26th of September, there was not a sufficient quantity of Early Amber cane ripe, and so Orange cane which was not mature was used from the 8th to the 20th of September. The quality of the cane worked continued to improve until late in the season. In regard to the character of the crop for the successful manufacture of sugar the season may be said to have extended only from September 25 to November 5. After November 5 the cane suffered rapid deterioration, rendering it extremely difficult to work it in the battery without serious loss by inversion. Freezing weather first occurred on the 3d of November, and this being followed by warm weather caused fermentation. The cane which had been planted on freshly turned sod suffered the least from the freeze and showed but little fermentation before the 10th of November.

In recapitulation it may be said that until September 25 the cane was in poor condition, that the indiscriminate mixing of Amber and Orange cane, which became unavoidable, was very unsatisfactory and that all the results obtained before the 25th of September were of little value except for the testing of the machinery.

SOURCES OF LOSS.

From the cutter and the centrifugal there were many opportunities for serious loss; fully 35 per cent. of the cane purchased was carried away in the cutters and cleaners. The loss in the battery by poor extraction and inversion was 13.6 per cent. of the entire sugar contained in the cane. In the remaining portion of the work the loss of sugar amounted to 10.9 per cent. of the whole sugar contained in the cane. The aggregate loss amounted to nearly 25 per cent. of the entire sugar in the crop. This immense loss is directly chargeable to defective machinery and largely due to delays in the working of the house. This is illustrated by the fact that during the season of 78 days 7,239 tons of cane passed the house, or 92.7 tons per day.

The financial failure of the factory must be ascribed directly to inefficient machinery; had the factory worked regularly from the 26th of August the receivership of the 19th of October would not have taken place. The numerous experiments conducted at Attica resulted, in general, successfully. The use of filter presses is to be highly commended. The apparatus for drying the sugar was also successfully worked. The attempt to burn the exhausted chips failed because of the crude, expensive, and inefficient apparatus employed in drying them.

The efficient services of Messrs. Watson and Deming did much to prevent the earlier dissolution of the company.

Summary of results of chemical control.

Cane purchased	tons	7,239.00
Cane, diffused, clean	do	4,702.80
Loss in cutting	per cent	35.10
Loss in cutting	tons	2,536.20
Loss in cutting	pounds	5,072,400.00
Juice in clean cane	tons	4,166.70
Juice in clean cane	pounds	8,333,400.00
Juice in clean cane	gallons	11,000.40
Average per cent. juice, clean cane		88.60
Sugar in cane	pounds	875,841.00
Glucose in cane	do	133,626.00
Sugar available (approximate)	do	675,402.00
Sugar present per ton, clean cane	do	186.20
Sugar present per ton, field cane	do	120.00

Losses.

At battery—	Losses.	Clean cane per ton.	Field cane.	Whole sugar.
	Pounds.	*Pounds.*	*Pounds.*	*Per cent.*
In extraction (total)	105,158	22.3	14.5	12.00
By inversion (total)	14,341	3.0	1.9	1.63
At double effect (total)	60,000	12.7	8.2	6.85
Battery to double effect (total)	35,377	7.5	4.8	4.04
Totals	214,876	45.5	29.4	24.52

Yield.

Sugar obtained (firsts)	pounds	262,038
Sugar in cane	per cent	29.91
Sugar in diffusion, juice	do	34.64
Sugar in semi-sirup	do	39.64
Sugar obtained (firsts)		262,038
Sugar obtained in semi-sirup		660,965
Sugar left in molasses		398,927
Glucose left in molasses (estimated)		128,539
Available sugar in molasses (estimated)		206,127
Total product first sugar, plus estimated seconds available	pounds	468,165
Yield per ton, field cane, firsts		36.5
Yield per ton, clean cane, firsts	pounds	55.7
Yield per ton, field cane (estimated) seconds	do	28.6
Yield per ton, clean cane (estimated) seconds	do	43.8
Yield per ton, field cane, total product		65.1
Yield per ton, clean cane, total product		99.5

Financial.

Cost of cane (7,184 tons)	$10,653.40
Cost of labor (sixty days)	9,857.58
Cost of fuel	2,791.32
Total expense of operation, August 24 to November 12	23,302.30
Fuel, cost per ton, cane	.38
Labor, cost per ton, cane	1.48
Cane, cost per ton	1.38
Total cost per ton, cane	3.24
Fuel, cost per 100 pounds, sugar	1.06
Labor, cost per 100 pounds, sugar	3.37
Cane, cost per 100 pounds, sugar	4.06
Total expense per 100 pounds sugar	8.49
Coal per 100 pounds sugar, pounds	905
Average labor per day (sixty days)	$140.28
Loss of time by delays in manufacture, season of twenty-eight days, per cent	18.20

Mean results of analyses.

[In the juice.]

	Total solids.	Sucrose.	Glucose.	Clean cane worked.	Sugar in cane.	Glucose in cane.
Fresh chips entering battery—	*Per cent.*	*Per cent.*	*Per cent.*	*Tons.*	*Pounds.*	*Pounds.*
From August to September	15.96	9 95	2.29	2,197.2	321.942	75,850
In October	17.72	12.69	1.51	1,914	426,952	43.972
In November	17.41	12.13	1.36	591.6	127,347	13,804

RECAPITULATION FOR THE SEASON.

Total tons clean cane worked for season		4,702.8
Average per centage of juice in cane		88.6
Total sugar in cane	pounds	875,841
Total glucose in cane	do	133,626
Total available sugar (approximate)	do	675,402
Sugar per ton of clean cane (means)	do	186.2

Sucrose in exhausted chips for the different periods of the season.

	Per cent.
August and September	.63
October	1.57
November	1.46
The season	1.46

Sugar inverted in the battery for the different periods of the season and for the entire time.

	Per cent.
August and September	.30
October	.14
November	.20
The season	.21

Composition of the diffusion juices for the different periods of the season.

	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
August and September	12.05	7.60	1.91
October	13.39	8.48	1.13
November	12.88	8.89	1.07

Composition of sirups.

	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent*	*Per cent.*
August and September	52.3	32.5	9.1
October	51.6	36.9	5.1
November	54.0	36.3	5.5

Mean composition of the massecuites for the season.

	Per cent.
Total solids	94.90
Sucrose	61.74
Glucose	12.16

First sugars, mean composition for the season.

	Per cent.
Sucrose	98.29
Glucose	.83

Molasses, means for the season.

	Per cent.
Total solids	85.31
Sucrose	39.42
Glucose	18.28

RESULTS OF CULTURE EXPERIMENTS.

Early Amber.—Planted on the 2d, 6th, 7th, and 16th of May. The highest per cents. of sucrose from this plot was 12.45, 12.00, 12.80, and 12.95, respectively, and the apparent time of maturing 123 days.

Chinese Cane.—The highest sucrose obtained was 14.90 per cent. on October 14; on November 7 the sucrose was still 13.70 per cent.; the apparent time for maturing 156 to 163 days.

Kansas Orange.—Highest sucrose obtained was 15.35 per cent.; the apparent time for maturing on different plots from 129 to 146 days.

Late Orange.—Highest sucrose obtained was 15.70 per cent.; apparent time of maturing on the different plots from 132 to 164 days.

Early Orange.—Highest sucrose obtained 14.65 per cent.; apparent time for maturing on the different plots from 129 to 163 days.

Early Golden.—Highest sucrose obtained 14.20 per cent.; apparent time of maturing on different plots from 131 to 146 days.

Link's Hybrid.—Highest sucrose obtained 14.70 per cent.; apparent time of maturing on different plots from 131 to 161 days.

Red Liberian.—Highest sucrose obtained 15.70 per cent.; apparent time for maturing on different plots from 131 to 161 days.

White African.—Highest sucrose obtained 14.00 per cent.; apparent time of maturing from 131 to 161 days.

Deutcher's Hybrid.—Highest sucrose obtained 12.96 per cent.; apparent time of maturing from 131 to 163 days.

Waubunsee.—Highest sucrose obtained 10.30 per cent.; apparent time of maturing from 129 to 158 days.

Goose Neck.—Highest sucrose obtained 13.00 per cent.; apparent time of maturing 185 days.

Honduras.—Highest sucrose obtained 10.30 per cent.; apparent time of maturing from 131 to 148 days.

Whiting's Early.—Highest sucrose obtained 9.00 per cent.; apparent time of maturing from 131 to 136 days.

Large numbers of other analyses were made on the culture plots, but

the above composes a summary of all the most important. The complete analyses, together with the analyses made for seed selection, will be kept on file in the Department.

MEDICINE LODGE.

ABSTRACT OF THE REPORT OF T. F. SANBORN.

The chemical work at Medicine Lodge during the first of the season was under the control of Mr. Hubert Edson. Mr. Edson having accepted a position in Louisiana, the latter part of the work was entrusted to Mr. Sanborn, who compiled the tables of analyses for the whole season.

Three hundred and twenty-three miscellaneous analyses were made of selected canes and canes from the field, with the following results:

[In the juice.]

	Total solids.	Sucrose.	Glucose.	Purity.
	Per cent.	*Per cent.*	*Per cent.*	
Means	16.67	10.21	1.48	61.24
Maxima	22.70	17.33	2.43	85.37
Minima	9.05	1.11	.83	9.90

JUICES FROM FRESH CHIPS.

Forty-nine analyses were made with the following results:

	Total solids.	Sucrose.	Glucose.	Purity.
	Per cent.	*Per cent.*	*Per cent.*	
Means	16.46	10.44	2.24	63.66
Maxima	19.12	13.45	4.52	77.97
Minima	14.70	8.27	1.03	47.64

Forty-nine analyses of the diffusion juices were made with the following results:

	Total solids.	Sucrose.	Glucose.	Purity.
	Per cent.	*Per cent.*	*Per cent.*	
Means	11.40	7.13	1.45	62.54
Maxima	14.23	8.89	2.59	70.70
Minima	9.01	5.20	.69	40.97

Forty-nine analyses of exhausted chips were made with the following results:

[In the juice.]

	Total solids.	Sucrose.
	Per cent.	*Per cent.*
Means	2.09	1.02
Maxima	2.89	1.54
Minima	1.34	.48

Forty-seven analyses of the clarified juices were made with the following results:

	Total solids.	Sucrose.	Glucose.	Purity.
	Per cent.	*Per cent.*	*Per cent.*	
Means	12.02	7.85	1.58	65.30
Maxima	14.82	9.42	2.83	79.46
Minima	9.90	5.22	.78	40.21

Forty-six analyses of the sirups were made with the following results:

	Total solids.	Sucrose.	Glucose	Purity.
	Per cent.	*Per cent.*	*Per cent.*	
Means	39.89	26.01	5.45	65.40
Maxima	47.97	32.26	8.94	73.31
Minima	27.06	18.12	3.21	51.26

Eleven analyses of massecuites were made with the following results:

	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
Means	92.16	56.31	18.12
Maxima	94.74	61.92	20.02
Minima	91.99	51.74	14.29

The mean analyses of the first sugars were as follows:

	Sucrose.
	Per cent.
Mean	98.0
Maximum	99.8
Minimum	95.1

The mean composition of the molasses was as follows:

	Per cent.
Total solids	83.33
Sucrose	42.43
Glucose	26.64

Mean composition of second sugars:

	Per cent.
Sucrose	89.7

MEADE.

ABSTRACT OF REPORT OF JOHN L. FUELLING.

On my arrival at Meade, the 23d of August, the sugar-house was but partially finished, with a poor prospect of a supply of water. The cane was short and dry and a very light tonnage per acre. It was rather the exception to find cane with a fully matured head, and in place of the usual black head of amber I found the cane bearing heads partially white and in some cases perfectly white. The differences in the cane made it imperative to have every load tested which was brought to the sugar-house. Most of the cane had also been ruined by a hail storm and in some cases by the grub worms from the larvæ of the lachnosterna. The cane at Arkalon was in a much better condition. So little cane was received from Liberal that a comparison is not made. In some cases analyses showed that cane which had been cut short by the drought so as to produce no head at all, gave a higher percentage of sucrose than cane which to all appearances was matured. This peculiarity is shown by comparison of three samples of cane, of which the first was a matured Orange cane with fully developed head, the second a sample of the same variety of cane in which the seeds were still in the milk, and the third a sample of the same variety of cane which had developed no seed head at all.

Serial. No.	Brix.	Sucrose.	Glucose.	Fiber.	Albuminoids.	Purity.
	Per ct.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
1.....	19.72	13.35	2.35	8.73	.7750	67.18
2.....	23.88	18.08	1.81	10.51	1.8000	75.71
3.....	21.49	15.34	2.31	12.32	1.0312	71.38

It was thought a sufficient supply of water could be had by boring an artesian well, but this was proved to be a mistake. After much delay a very deep, large well was dug which furnished a moderate supply of water. There was similar trouble at Arkalon, making it necessary to lay a line of pipe to the Cimarron River. The factory at Liberal was supplied by two artesian wells. The incomplete condition of the works made it impossible to start them until the season was practically at an end, giving them only a little over a week for actual work. The double-effect pan was the source of much trouble and loss; the compartments being entirely too low, the juice on boiling would pass into the coils of the next effect and out into the ditch. The poor extraction in the battery was chiefly due to the coarse chips. The ensilage cutter gave entire satisfaction, doing all that could be desired.

Only one strike of sugar was made at Meade and Arkalon and two at Liberal. The work being of such short duration it was impossible to get a desirable system of control.

There was also no attempt to observe that economy which is necessary to make a success of the sorghum industry. Skimmings showing 5.25 per cent. of sucrose were thrown into the ditch; it was only when, as a last resource, I appealed to the president of the sugar company, I was promised that this loss should be corrected.

According to instructions, I visited the Minneola Sugar Works, where the roasting process was on trial several times, but never succeeded in getting any information nor samples, inasmuch as the works were invariably shut down on my arrival.

Many hundreds of analyses of cane were made, and the following are the averages of some of the most important varieties:

Averages of special canes.

[In the juice.]

Marked.	Varieties.	Sucrose.	Purity.
		Per cent.	
1	Cane grown on an up-land	8.34	52.14
2	Cane grown on low-land	10.82	62.91
3	Cane grown on gypsum soil, spring plowing	10.54	58.22
4	Cane grown on gypsum soil, fall plowing	13.14	65.88
5	Cane grown on first year's sod	10.77	63.00
7	Cane grown on old sod	8.68	42.82
11	Samples of cane that were pithy and red	5.70	42.88

One hundred and fifty-five analyses of selected cane were made at Meade with the following mean results:

[In the juice.]

Total solids	per cent..	16.29
Sucrose	do....	9.00
Purity		55.66

Fifty-eight analyses of cane were made at Arkalon with the following mean results:

[In the juice.]

Total solids	per cent..	16.04
Sucrose	do....	9.14
Purity		56.98

Twelve samples of fresh chips entering the battery at Meade, were examined with the following mean results:

[In the juice.]

Total solids	per cent..	18.02
Sucrose	do....	10.61
Glucose	do....	3.85
Purity		58.88

Nine samples of diffusion juice were examined at Meade with the following mean results:

Total solids	per cent..	10.19
Sucrose	do....	5.60
Glucose	do....	1.82
Purity		54.95

Thirteen samples of exhausted chips from the battery were examined with the following mean results:

[In the juice.]

	Per cent.
Total solids	4.05
Sucrose	1.86

Eleven samples of sirups were examined with the following mean results:

Total solids	per cent	47.92
Sucrose	do	27.89
Glucose	do	7.62
Purity		58.20

Three samples of massecuites from Meade were analyzed with the following mean results:

Total solids	per cent	92.36
Sucrose	do	56.66
Glucose	do	13.52
Purity		61.21

Three samples of sugar were analyzed with the following mean result:

	Per cent.
Sucrose	93.60

Three samples of molasses were examined with the following mean results:

Total solids	per cent	81.16
Sucrose	do	38.61
Glucose	do	16.12
Purity		47.67

NESS CITY.

ABSTRACT OF REPORT OF K. P. MCELROY.

No sugar was made by the Ness County Sugar Company, a fact wholly attributable to the poor quality of its crop. The mill was started September 26, and was operated at intervals until October 15. The water supply was wholly inadequate for a sugar-house, and although but little work was done there was not enough water to supply battery, triple effect, and strike pan simultaneously. Out of 1,500 acres planted in sorghum there was scarcely enough to supply the mill ten days had it been running full capacity.

The cane entering the mill was even of worse quality than shown by the means of the analyses given. No care was exercised to insure prompt delivery of cane after cutting, and in many cases it lay several days in the field. After reaching the cane platforms affairs were not much better, for the incessant stoppages incident to complete and operate the mill simultaneously caused the cane to lie indefini' ' the platform.

The seed was purchased at Sterling, 100 miles east, but the soil and climate of the two places are radically different, and while the crop at Sterling was fine the crop at Ness City was a failure.

One hundred and ninety-five analyses of single canes and samples of cane from the field were made, showing percentages of sucrose ranging from almost nothing, viz: .10 per cent. to cane of fair quality, in one instance 15.23 per cent.

The fresh chips, exhausted chips, and diffusion juices entering the battery and representing fairly the cane manufactured, had the following composition on the dates mentioned:

Analytical Data.

Date.		Brix.	Sucrose.	Purity.	Glucose.	Ratio.
		Pr. ct.	*Per cent.*		*Per cent.*	
Sept. 26	Fresh chips	18.67	8.38	45.06	5.32	59.40
Sept. 26	Exhausted chips	4.51	1.82			
Sept. 27	Fresh chips	17.79	6.94	39.14	5.22	75.22
Sept. 27	Diffusion juice	8.55	3.22	37.68	2.73	84.78
Sept. 27	Sirup	53.19	19.92	37.45	20.19	101.35
Sept. 27	Exhausted chips	1.01	.77			
		Extraction 88.90 per cent.; dilution 110.4 per cent.				
Sept. 28	Fresh chips	18.41	8.10	44.00	3.13	38.64
Sept. 28	Diffusion juice	9.61	3.92	40.79	3.09	79.59
Sept. 28	Exhausted chips		.85			
		Extraction 89.50 per cent.; dilution 91.50 per cent.				
Sept. 29	Fresh chips	16.71	6.66	39.86	5.08	76.28
Sept. 29	Exhausted chips		.60			
		Extraction 91.00 per cent.				
Sept. 30	Fresh chips	17.70	6.68	37.74	6.46	96.70
Sept. 30	Diffusion juice	10.04	3.87	38.55	3.94	101.80
Sept. 30	Clarified juice	9.53	4.23	44.39	4.19	99.05
Sept. 30	Exhausted chips	1.52	.32			
		Extraction 95.21 per cent.; dilution 76.2 per cent.				
Oct. 1	Fresh chips	15.71	5.46	34.75	6.41	117.40
Oct. 1	Diffusion juice	10.61	3.74	35.25	4.43	118.45
Oct. 1	Sirup	47.04	16.45	34.97	20.26	123.16
Oct. 1	Exhausted chips	2.03	.48			
		Extraction 91.21 per cent.; dilution 48.1 per cent.				
Oct. 10	Fresh chips	14.07	3.66	26.02	6.44	175.95
Oct. 10	Diffusion juice	10.36	3.12	30.12	4.49	143.91
Oct. 10	Clarified juice	9.96	3.07	30.83	4.39	143.00
Oct. 10	Exhausted chips	2.03	.22			
		Extraction 93.99 per cent.; dilution 35.8 per cent.				
Oct. 11	Fresh chips	14.81	5.47	36.93	5.77	105.49
Oct. 11	Diffusion juice	10.39	3.20	30.80	3.07	95.94
Oct. 11	Clarified juice	9.57	2.86	29.82	2.72	95.11
Oct. 11	Sirup	35.30	12.50	35.41	19.67	157.30
Oct. 11	Massecuite	81.50	23.30	28.59	33.33	143.05
Oct. 11	Exhausted chips	3.08	.93			
		Extraction 83.00 per cent.; dilution 42.5 per cent.				

METHODS OF IMPROVING SORGHUM.

ABSTRACT OF REPORT OF A. A. DENTON AND C. A. CRAMPTON.

STERLING, KANS.

It has been proven by the thousands of analyses of sorghum juices which have been made by the Department of Agriculture, that sorghum canes often contain a fair percentage of crystallizable sugar, sometimes as much as tropical sugar-cane, or as the improved sugar-beet. It has also been shown that similar canes grown under apparently similar conditions often contain but little sugar, and that sorghum canes are variable in quality.

One object of this experimental work has been to determine the causes of this variableness, and to determine whether the cane can be bred up to uniformly good quality.

There are two classes of plants which can be improved with difficulty. One of these classes consists of plants which are of fixed types, in which the individual plants vary but little, and which readily revert to the original type. The other class consists of plants which are so variable that they can with difficulty be reduced to fixed types having uniform qualities. As sorghum is a variable plant, its improvement implies that it should be bred to certain fixed types which will have uniform qualities.

The lines in which the improvement of the plant should be carried out were laid down by us in Bulletin No. 20, as follows:

(1) By growing and testing all known varieties and selecting the most promising.

(2) By hybridizing or crossing these varieties.

(3) By preserving "sports" or variations.

(4) By selecting seed from the finest individual canes of each variety.

(5) By improved methods of cultivation.

All of these methods were practiced to a greater or less extent in the work in 1888, and this season's work has been practically a direct continuation of the first years work, with such modifications as were suggested by the experience of one season. The results and conclusions attained in each direction will be set forth in the order given above.

1.—Experiments in growing different varieties of cane.

The first step in this work is the collection of varieties of sorghum from all countries where sorghum is grown, and a comparison of the qualities of the canes. After this has been done there are difficulties in the way of selecting the best varieties. It is well understood by horticulturists that plants sometimes gain, sometimes lose, by a change to new conditions of soil and climate; they require time to adjust themselves to new conditions. It is also well understood by agriculturists that a certain variety of a plant may excel all other varieties in one season, and yet may be excelled by other varieties in another season.

These variations are caused partly by known and partly by unknown causes, some of which may be beyond the control of the agriculturist.

Judged by the average results of a term of years it may be decided that a certain variety is pre-eminently suited to one section of the country. If the results of one season's trial of a variety are good it is encouraging, but it requires confirmation.

When the beet-sugar industry began it met the same difficulties in selecting the best varieties. The common beet was found wild along the coast of the Mediterranean, species were found in Western Asia and in Northern Africa. These varieties differed in form, in color, in size, and in sweetness. Some contained but 2 per cent. of sugar and cor-

responded to the non-saccharine varieties of sorghum. It was found that the white Silesian variety contained most sugar and least impurity. This variety was selected, and from it the best improved varieties of the present day have been developed. This selection of the best variety and the development of improved varieties required time, and occasioned the remark, "The beet-sugar industry began 140 years ago, and for half of that time no one could make it pay."

RESULTS OF TWO SEASONS' WORK APPLIED TO THE WEEDING OUT OF INFERIOR VARIETIES.

All the varieties grown last year, whether they had done well or not, were planted again this year. Even two years' growing of a variety is not fully conclusive as to its merits, and observations extending over a term of several years would be required to determine absolutely that a variety was decidedly inferior and incapable of rapid improvement; yet the varieties of sorghum are so numerous, and differ so widely in their qualities, that it would seem a waste of time to adhere longer to varieties that had shown uniformly poor qualities for two years in succession. We would therefore recommend, in case of a continuance of this work, that such varieties be thrown aside and attention concentrated on the numerous varieties which have shown good qualities during both seasons at this station, and to those varieties which have shown marked excellence at least one season in some particular direction, though not in all, with the expectation that they might be improved in the qualities where they were still lacking, by some of the methods of improvement.

CONTRAST BETWEEN THE CHARACTER OF THE GROWING SEASONS OF 1888 AND 1889.

While the work at this station has only been continued over a space of two years, the diversity of climatic conditions existing during these seasons has contributed greatly towards making a fairly complete test of the relative merit of different varieties. The season of 1888 at this point was exceptionally dry and hot; the season of 1889 was just the reverse—exceptionally wet and cold. The growth of the cane was consequently very different. In 1888 it made a short growth; the amount produced to a given area of ground was small and the cane ripened early. In 1889 the growth was very heavy, the amount produced to a given area was nearly twice as great as in the preceding year, and the time of maturing was at least two weeks later. These two contrasting seasons, therefore, constitute a pretty severe test of the different varieties, and such of them as made a favorable showing in both can be pretty safely depended on to have permanent good qualities. Varieties that made a good showing in the one season and not in the other could not properly be condemned, however, as the conditions may have been particularly severe on them. In 1889, for example, the late season did

not permit of the ripening of some of the late varieties before frost, although the previous season the highest analyses obtained were from these same late varieties.

II.—Experiments in hybridizing or crossing varieties. III.—Experiments in preserving sports or variations.

After the best of the known varieties have been selected, the next step is the improvement of these varieties, which may be accomplished by causing or promoting variations among them, and thus obtaining new and improved varieties.

The success of the beet-sugar industry is based upon the improved varieties which the beet growers have created. The success of the sorghum industry will be based upon the possibility of procuring improved varieties.

In 1860, when Vilmorin was producing his famous variety of the beet known as the "Improved Vilmorin," he resorted to crossing varieties, and then to selection of seed from the best of the crossed plants. Many of the finest fruits have been crossed and recrossed many times. Then, again, many valuable varieties of plants have originated in so-called "sports" or variations which have suddenly appeared in some unknown way. It is probable that these are often simply accidental or unknown crosses.

In the work at this station the experiments in this direction have been confined to this class of variations, the large number of plots and press of work having prevented experiments in the line of artificially produced crosses.

In the following analyses it will be seen that we have selected many of these variations of unknown origin from among canes of well known varieties; some of them differ from all known varieties of sorghum, some of them have much higher percentage of sugar than the varieties from which they were taken. In fact, these variations are new varieties. It will be remembered that the Early Amber, which is now perhaps the most widely distributed variety of sorghum, is said to have been a chance variation found in a field of the "Chinese" variety, and also that Link's Hybrid, which, if not the best variety for sugar manufacture, is one of the best, originated in a variation found in a field of the Honduras variety.

There is no doubt that remarkable variations in type, in time of maturing, and in quality of juice are produced by crossing varieties, or that permanent new varieties having new characters and qualities may be produced by crossing varieties of sorghum. In many of the lots in the experimental field which were planted with the seeds from a single crossed cane the variations in the qualities of the individual canes were so great that it was not possible to take average samples of cane from those lots which would give comparable analyses. Here is opportunity for the skilled horticulturist to select a single crossed cane of desired character and of unusual percentage of sugar, and to fix its extraordi-

nary qualities by repeated selections, and thus create an improved variety. It is possible to combine the good qualities of two good varieties. Our analyses show that some crosses mature earlier than the late maturing parent varieties, that some have very high percentages of crystallizable sugar, that some have very low percentage of uncrystallizable sugar, that some have high purity of juice, and some give a large yield of cane per acre.

"MIXING" OR ACCIDENTAL CROSSING OF VARIETIES.

The indiscriminate crossing of varieties, caused by seeds of more than one variety being planted together, is, of course, an unmixed evil so far as sugar manufacture is concerned. But our work and observations at this station for the past two years have convinced us that the extent to which such crossing occurs between varieties planted in juxtaposition has been greatly exaggerated.

It has been said that varieties of sorghum will mix across a 40-acre field, and that broom-corn makes sorghum which grows a mile away worthless for sugar manufacture. We have carefully observed the evidences of crossing, and have not yet seen proof that crossing occurs at a considerable distance. It is observed that sorghum does not produce pollen in such profusion as corn. With sorghum there is no necessity for such excess of pollen. It is true with sorghum, as it is with most other plants, that when seeds of two or more varieties are planted together or in close proximity, crossed plants sometimes appear the next season from germs of those seeds which were cross fertilized the first season. It is easy to understand that seed-tops swayed by the wind may come in contact with seed-tops of other canes. Crossing of varieties, however, is not as frequent as is supposed. We have frequently intentionally mixed thousands of seeds of two varieties and planted them together for the purpose of producing a cross between those varities, and in the following year we have often found but few, sometimes none, of the thousands of canes produced by those exposed plants to show the desired cross.

The continuous planting for many years of sorghum seeds which have been accidentally cross-fertilized in greater or less degree has, however, produced endless variations in type, in time of maturing, and in quality of ordinary sorghum canes. In many hundred packages of sorghum seeds received at this station from many countries there were but few, if any, in which variations caused by crossing could not be found.

It has also been said that where broom-corn or other non-saccharine varieties of sorghum are extensively grown sorghum cane is worthless for sugar manufacture. It has been said that sorghum canes which grew near a field of non-saccharine varieties contained but 2 per cent. of sugar. It has been said that sorghum growing in France for the production of alcohol from the sugar in the canes was abandoned on account of the deterioration in the quality of the canes produced by

crossing with broom-corn.[1] But it is not possible by any known means to modify the character of any plant at any period of its growth after the germ which produces that plant has been formed. The germ of the seed contains the destiny of the plant. If the history of the germ is known, the character of the plant which it produces is also known.

Circumstances may modify the development of the plant, but they can not change the type or the nature of the plant. Sorghum seed of pure variety planted with broom-corn or other non saccharine varieties produces as good canes with as high sugar content as if planted alone. The germs of the seeds produced by these canes may, however, be fertilized with pollen from the non saccharine varieties, and the plants of the second generation may thus be worthless for sugar manufacture.

It follows from these facts that when pure sorghum seed is planted each year it is immaterial what varieties are grown in the adjacent fields, but the seed for the succeeding year should not be saved from such fields, but a fresh supply should be procured from a seed farm or establishment for the production of pure seed. In such an establishment, of course, all doubt in regard to the purity of the seed should be removed by making continuous selections of seed from year to year, and by planting the selected seed in widely separated lots, as is done in growing "special" beet seed for sugar manufacture. Unfortunately it has not been possible to do this with the seed raised at this station so far, and we are unable to guaranty absolutely the purity of the varieties. The facilities and allowances have been so meager and the range of the work so extended that sufficient space could not be given the different plots. We have had to determine the qualities of all the varieties, to study the tendencies of selection and of crossing, and to learn the methods of improving the sorghum cane. It has not hitherto been possible to plant four hundred separate packages of seed on four hundred separate farms. In continuing this experimental work with a view to the selection of pure seed of the best varieties it is recommended that a much larger area of land be used for this purpose than has previously been used, and that it be land upon which sorghum has not before been grown, so as to do away with the difficulty arising from volunteer cane.

IV.—Experiments in the selection of seed from individual canes showing a high content of sugar.

The importance of this method of improvement and the probability of obtaining good results by following it up were set forth in last year's report, but perhaps some further reference to its employment and success in the beet industry will not be amiss. Stammer[2] speaks of it as follows:

In the last few years the necessity for seed selection from the richest beets has become more apparent. * * * Though this was true in previous times, yet now

[1] Hippolyte Leplay, Bull. 18, p. 180. [2] Lehrbuch der Zuckerfabrikation.

more than ever the condition of the factories demands rich beets. * * * While formerly it was sought to accomplish this object by pure breeding of the best varieties, now more prominence is attached to the selection of seed from individual beets of the highest sugar content and purity. * * * It was only after people had learned to select beets for seed first by their outward characteristics, then from these according to their sugar content, that beets were produced which combined excellence of form and of sugar content. * * * In conclusion, it may be said that too great emphasis can not be laid upon the fact that no other branch of the subject deserves greater attention from beet-sugar growers than the planting of the best seed.

In the present condition of the sorghum-sugar industry, and in the undeveloped condition of the sorghum plant, these statements have special force and should have the careful consideration of sorghum-sugar growers.

TIME REQUIRED FOR IMPROVEMENT IN VARIETIES OF SORGHUM BY SELECTION OF SEED

In Bulletin No. 20 attention was called to the advantages possessed by sorghum over other sugar-producing plants in the ease with which seed could be selected from the best individuals by the analysis of the juice.

While an increased yield of sugar may be speedily obtained by a single selection of seed and by separate planting and by careful cultivation, the development of pure-bred seed of improved varieties will require more time.

PROGRESS MADE IN THIS DIRECTION THE PAST SEASON.

Unfortunately we can not report much progress in this line of improvement during the past season. In 1888 the selections of seed heads by analysis from standard varieties covered comparatively a small range of individuals from a few standard varieties only. The work of selection began late in the season, and consequently was confined entirely to the late varieties, such as Liberian, Early Orange, etc. But these late varieties were the very ones that did not mature this season, so it was impossible to determine whether any improvement had been made. With the exception of these late varieties, nearly all kinds of cane made a better showing in analysis this year than last. It was a better season for the development of the sugar content of sorghum cane. The analysis of average samples from plots which were planted from single seed heads that had been selected for some special reason, such as peculiarity of form, and of which the analysis was known, shows almost invariably a higher analysis than the cane from which the plot was planted. This improvement could not be attributed to selection for a single season, but was due to the better growing season, as already stated.

This year more work was accomplished in the selection of fine indi-

vidual canes from standard varieties, and a better foundation was laid for the prosecution of this method of improvement in future years. Nearly every variety which showed good general results was subjected to selection of individuals by analysis, and a large number of seed heads obtained, with a high "record" for one season. It is not to be expected that the canes produced from these seed heads next year will necessarily show higher, or even as high analyses as the parent cane from which they came. Next season may be as exceptionally bad as this season was exceptionally good for the production of fine canes. Even if the seasons are equal in this respect, it will not show that the plant can not be improved in this direction.

It is not reasonable to suppose that seeds from a cane of extraordinary quality will produce canes of as extraordinary quality as the parent cane, for this implies that a greatly improved variety can be produced by a single selection. A gradual and general improvement, after selections extending over several years, is all that could reasonably be expected.

IMPORTANCE OF PLANTING SEED WHICH WILL PRODUCE CANES WITH A UNIFORM TIME OF RIPENING.

Independently of the matter of improving varieties of sorghum by selecting seed from the best individual canes, it seems to be clearly proved by the experimental work that very great improvement in the yield of sugar may be made by selecting and planting together those seeds of a variety which mature at one time.

In all ordinary fields of sorghum it is noticed that all the canes of one variety and of one planting do not mature at the same time even if the variety is pure and unmixed with other varieties; they vary in maturing from two to four weeks. These differences in time of maturing are almost sufficient to account for the considerable differences in sugar content which are found in the individual canes in one row of one field. It is well known that immature canes, and also over-ripe canes whose juice has deteriorated, have a low percentage of crystallizable sugar and a high percentage of uncrystallizable sugar. In practical work it is not possible to harvest only the canes which are in their best state, and thus, although the individual canes in a field have, or have had, or would have if left longer to mature, a fair percentage of sugar, yet the average yield of sugar from all the canes harvested at one time will be small. It follows from these facts that although sorghum seed may seem pure and unmixed with seed of other varieties, yet if it contains subvarieties which mature at different times this will lessen the yield of sugar, for there will be differences in degree of maturity, and consequent differences in sugar content in the individual canes, and the average yield of sugar will be low.

PLOTS PLANTED FROM A SINGLE SEED HEAD.

The advantage of raising canes with a uniform period of ripening was beautifully illustrated in the experimental field this season by the plots which had been planted from a single seed head of a pure, well-established variety. The canes in such plots, without exception, came up, and grew and ripened with a remarkable degree of uniformity. The tops of some plots were like level floors, and there was probably not a week's difference in time of maturity amongst the individual canes. The canes were uniform not only in time of maturing, but also in type and in analysis. In plots planted with seed taken from a general lot, on the other hand, the differences in type, in time of maturity, and in analysis were apparent even to the unobservant.

If now it were possible to plant an entire field with the seed from a single cane, and thus secure the same degree of uniformity we obtained in our small plots, nothing better could be desired. This can not be done, of course, but it is reasonable to suppose that seed heads selected from such a uniform collection as our plots would produce a field of cane in which the individuals would approximate closely in maturity and in type, even though they came from different seed heads. A single seed head will plant a pretty large area of ground, and from the cane it produces enough can be selected the second year to plant a large field.

If for no other purpose than to secure this essential uniformity, we would recommend sorghum growers to obtain their seed for planting in this way: To obtain a single seed head from a good and pure variety, from which it has been selected for exceptionally good results on analysis. This will correspond to the "mother" beet in beet culture, and the seeds from this head should be planted in a separate plot and all possible precautions taken to prevent their being contaminated or cross-fertilized from other canes. Uniformity should be further secured by care in cultivation, and even covering, so as to secure an equal chance for all, and there is little room for doubt that the seed from these canes will produce a field of exceptional evenness of type, of time of maturity, and of sugar content.

We regard this method of "family breeding" as the best calculated to overcome the variableness of sorghum and to produce fixed types of uniform qualities.

If one thousand canes are taken from one variety on the 1st of September and examined separately, and if from these three or four seed heads are selected from the canes which contain most sugar, then it is evident that while selecting canes of unusual quality selections are also made of canes which mature at that date; and if on the 1st of October one thousand canes are again taken from the same plot, and if from these similar selections are made, then it is evident that while selecting canes of unusual quality, selections are also made of canes which ma-

ture a month later than the first selections. The mixture of seeds from these subvarieties which mature a month apart is especially to be avoided; it nullifies the effort to produce canes which ripen at the same time. Selections by analysis, made when the plot on an average is immature, picks out the early ripening canes; selections made when the plot on an average is over ripe, rejects all but the late ripening canes. In order to have the selection based as much as possible upon relative good qualities of the canes, such work should therefore be done as nearly as possible when the greater part of the whole plot is at the maximum of maturity, and this is made much easier if the plot is itself fairly uniform.

Early selections may of course be practised in an endeavor to improve a variety in early ripening. It is evident that both earlier, and also later maturing subvarieties of sorghum may be formed by continued selections of early or of late maturing canes from one variety; the effect of early, and also of late selections from the late maturing Honduras variety will be seen in the analyses of different plots of that variety. Where a variety is to be maintained in its integrity and normal condition, however, selections from it should be made only at one time, and that time when it is neither under nor over ripe.

Another argument in favor of "intensive breeding," that is, taking a single seed head as a starting point, preserving the succeeding generation intact, and endeavoring to promote uniformity amongst canes in the plot, may be found in the fact that analysis may not give a proper indication of the quality of the seed of the cane analyzed, if cross-fertilization has taken place between it and neighboring canes. Suppose, for example, that a cane is selected by analysis from a plot in which there is not much uniformity among individuals; the simple fact that it had been selected on account of its very high analysis would imply that the canes around it were much inferior. If its seeds have been fertilized by pollen from any of these inferior neighbors, they will be just as likely to transmit their inferior qualities as the good qualities of the parent stem, and the high analysis of the latter would therefore be no guaranty of the quality of the seed taken from it. Were the parent stem surrounded by individuals of as high, or nearly as high quality as itself, this danger would be avoided.

V.—Experiments in improvement by methods of cultivation.

The methods of cultivation employed at this station have been perhaps sufficiently set forth by us in our previous report. We can only emphasize the necessity of care in following the details of the directions given, and would desire, as evidence of the correctness of our method and of the good results which can be obtained by careful cultivation, to call attention to the many fine plots of cane raised at this station the past season.

It is difficult to make apparent on paper the good quality of these plots,

for the analyses do not show the handsome appearance and fine growth of the cane, or its uniform ripening and even character. Some indication may be had, however, from the following table, giving the yield per acre of a few plots, obtained in a manner to be described later on :

Variety.	No. of pot.	Yield per acre.
		Tons.
Planter's Friend	186	19½
Do	376	26⅓
Ubehlana	226	21⅓
Plot No. 24 (1888)	227	28⅓
Plot No. 14 (1888)	228	18¼
Late Orange	239	21⅓
Do	386	22¼
Unde debulo	254	18⅓
Plot No. 52 (1888)	258	21⅓
Early Orange	382	29
Honduras	115	24
Do	383	33¼

This list includes only a few plots which were standing nearly intact at the close of the season, and the yield in many others was fully as high. Yet, notwithstanding the heavy growth, the sugar content was very good, the cane was uniform, and the analyses of average samples corresponded well with one another. There could be no question whatever of successful sugar manufacture from fields of such cane, and we see no reason why large fields of similar cane should not be produced as well as small ones by the same care in planting and cultivation.

DETERIORATION OF SORGHUM AFTER BEING CUT.

It is unfortunate that canes rapidly deteriorate, if they remain long unworked after being cut. This fact adds greatly to the difficulties of sorghum sugar manufacture. In practical work, unavoidable losses occur from the rapid deterioration of the canes. It is probable that there are considerable differences in the varieties in their keeping qualities, but we are not aware that any experiments have yet been made to determine their relative keeping qualities and it may be well to call attention to this point. It is reasonable to suppose that sorghum cane of an improved variety, having high purity and 20 per cent. of sugar will deteriorate less rapidly than sorghum cane which has low purity and but 10 per cent. of sugar.

The various experiments that are on record in respect to the loss of sugar in siloed cane also, would seem to indicate very marked differences in the keeping qualities of different varieties. Professor Cowgill, for example, in October, 1884, buried one ton of Link's Hybrid, and one ton of Orange cane, covering with three inches of soil. The canes were taken up and analyzed in the following January, and his conclusion was that the Link's Hybrid canes had sustained no loss of sucrose by being buried three months, while the Orange canes had lost nearly 5 per cent. A similar experiment made at this station may be given a place here as a contribution to the study of this point. On October 19

5 tons of cane were taken from a plot of Early Orange, and the same amount from a plot of Late Orange; the canes were covered in a very simple and expeditious manner by throwing a furrow from each side upon the cane laid lengthwise along the row. On December 2 the buried cane was taken up, passed through the large five-roller mill of the Sterling Sirup Works, the juice from the entire 5 tons of each variety collected in separate tanks and analyzed, together with analyses of the juice from an average sample of cane from the same plots, taken just before the plot was cut up, and passed through the small hand-mill.

	Before burying, October 19.				After being taken from silo, December 2.			
	Brix.	Sucrose.	Glucose.	Co-efficient of purity.	Brix.	Sucrose.	Glucose.	Coefficient of purity.
	°	*Per cent.*	*Per cent.*		°	*Per cent.*	*Per cent.*	
Early Orange	15.64	10.87	2.11	69.50	16.80	9.62	2.75	57.30
Late Orange	16.34	11.56	1.80	70.74	16.20	9.23	2.66	57.00

The analyses show a loss of sucrose in the Early Orange of 1.25 per cent., and a gain of .64 per cent. of glucose; and in the Late Orange a loss of 2.33 per cent. of sucrose, and a gain of .86 per cent. of glucose. The purity was much less after siloing in both cases. The samples are not so closely comparable as could be desired, the first juice being expressed by a hand-mill, and the second from a large double crusher.

PRESERVATION OF SORGHUM BY THE ADDITION OF SUBACETATE OF LEAD.

A portion of each of the large samples of the juice from buried canes mentioned above was preserved by the addition of a small quantity of subacetate of lead, and sent to the laboratory at Washington for analysis. A comparison is made of the analyses made at this station and at Washington in the following table:

EARLY ORANGE.

	Brix.	Sucrose	Glucose.
	°	*Per cent.*	*Per cent*
Analysis made at the Sterling Station	16.80	9.62	2.75
Analysis of same juice made at Department laboratory at Washington	16.80	9.73	2.19

LATE ORANGE.

	Brix.	Sucrose.	Glucose.
	°	*Per cent.*	*Per cent.*
Analysis of juice made at the Sterling Station	16.20	9.23	2.66
Analysis of same juice made at Department laboratory in Washington	16.20	9.33	2.54

The analysis at Washington was made seven days after the juice had been expressed, but the two analyses agree very closely, and show that the juice had not suffered the slightest deterioration. It is interesting to know that sorghum juice can be preserved for so long a time by lead, and it may prove useful in sending samples some distance for analysis. We have often received at this station samples of cane for analysis, sent by express from remote points. Such samples are generally so much deteriorated by the time they arrive, that an analysis gives but slight indication of their quality. Where access can be had to a mill, it would be much better to express the juice from a considerable quantity of the cane to be tested; collect and mix in a common receptacle; add a small quantity of subacetate of lead to a definite volume of the juice, and send to the laboratory by express. A sufficient quantity of the prepared solution of subacetate of lead can easily be furnished on application by any laboratory equipped for sugar work.

EFFECT OF RAIN ON THE JUICE CONTENT OF SORGHUM.

The analyses of Dr. Collier, in 1883, showed that three days' heavy rain, after a period of drouth, caused a loss of over 3 per cent. of sugar in sorghum canes. In the work here this season it was noticed that, after a week of almost continuous rain, the analyses of the varieties sampled during this period were lowered. As the analyses are based upon the juice, and not directly on the cane, it would seem possible that this apparent loss was due simply to a dilution of the juice content of the canes.

A beginning was made at this station the past season to determine the content of marc in the different varieties, but on account of press of work and lack of assistance it could not be carried out. The following determination would show that considerable range in juice content might be found in such an investigation:

	Per cent.
Marc in cane from plot of a non-saccharine sorghum	27.65
Marc in cane from plot No. 258 (sorghum bicolor)	11.46

The non saccharine varieties are as a rule inclined to be pithy and dry, and it is not likely that saccharine canes would show nearly so high a content of marc as the non-saccharine sample above.

LARGE SEED HEADS INDICATIVE OF SMALL SUGAR CONTENT IN CANES.

It was observed and noted by us last year that in selecting canes by analysis those which were of extra high percentage of sugar had small seed heads. This year's work has confirmed this observation, and it can almost be laid down as an established rule that individual canes having larger seed heads than their fellows have also a low content of sugar, and that varieties producing a large yield of seed do not show as good average analyses as varieties with small seed heads. It was

also observed this season that in the plots which were planted with seed from a single cane of extra quality the canes as a rule had also inherited small seed heads, in some cases not yielding half the usual amount of seed. There were, however, some exceptions to this rule.

In the absence of better means of selection it would seem better for the sorghum-grower to reverse the usual custom of selecting large and fine heads for seed, and select rather good-sized canes which have small seed heads.

It is probable that where improved varieties of sorghum have been produced sorghum will be more a sugar-producing plant, and less a grain producing or cereal plant.

DIFFERENCE BETWEEN VARIETIES IN RESPECT TO THE LENGTH OF TIME THEY RETAIN THEIR MAXIMUM OF SUGAR.

It was said by M. Hardy, director of the Central Government Gardens at Hamma in Algeria, that sorghum canes remained standing in the fields for months after maturity without loss of sugar. M. Bourdais, of Constantine, Algeria, also observed that sorghum canes long retained their value, and the same was said of sorghum by M. Balguerie, of Guadaloupe. It will be observed that some new varieties in the experimental field retained their maximum sugar content much longer than is usual with the ordinary varieties. Whether this is due to a very slow ripening of the seed in such varieties and consequent gradual storage of the sugar, or to an inertia of cell growth and consequent gradual reabsorption of the sugar, or to some other cause, are questions that can not be answered in the state of our present knowledge of the physiology of sorghum cane; but these differences seem to be quite constant.

The Early Amber and the White African, for instance, deteriorate rapidly. The Link's Hybrid and some others are much more durable in quality, and it is possible that still more durable varieties may be found.

It is evident that a variety which long retains its sugar would greatly assist the cane grower and the sugar manufacturer, for it allows longer time for working the crop. It has also a very great advantage in that it allows all the canes to ripen before any deteriorate. In selecting a variety this point should be considered. As no one variety of sorghum is so durable in sugar content that a single planting will furnish cane for the entire season, it is necessary to plant varieties which mature at different times, or to make successive plantings of one variety. With late maturing varieties successive plantings are not profitable, for these varieties require the entire growing season to attain their maximum sugar content. It is a problem of no little difficulty for the sugar grower to arrange the planting of varieties or to proportion successive plantings so that the canes will attain their maximum of sugar in sufficient but not in excessive quantities to make a long, continuous run of the factory.

It will probably be found best to plant in addition to the usual early

and late varieties a medium maturing variety, which will come in between the early and the late, and not only fill the gap between them, but also guard against a heavy loss of cane from a very early or very late season.

GENERAL DESCRIPTION OF THE WORK DONE THE PRESENT SEASON AT THIS STATION.

Four hundred and four separate plots were planted this season with seeds of numerous varieties of sorghum, with seeds of selections made last season, and with crosses. The experimental field comprised about 39 acres, being the same ground that was used in last years work. About 100 separate plots were planted in seed selections from canes of unusual quality, or from canes of unusual type; about 100 separate plots were planted in seeds taken from crossed canes, and about 200 separate plots were planted in seeds of the varieties of sorghum.

The planting began April 22, and was continued until July 13. The seeds were planted by hand, covered uniformly with soil to a depth of 1 inch; the planting was done in moist soil, following the plow closely; no thinning out of plants was done, and the stand of cane was almost perfect, except in a few plots in which from unknown causes seed which was apparently perfect failed to grow. The cultivation was deep and close while the plants were small; then deep cultivation was only done in the middle of each row, and when the fibrous roots extended, the cultivation was finished with a one horse harrow having many short teeth, and having the width adjusted, so as to take all the surface in the space between two rows of cane; the surface soil was thus harrowed once each week to a depth of 1 inch after the plants became large, until the canes were 10 to 12 feet high.

Some plots were washed out by flooding rains in the early spring, some were destroyed by chinch-bugs from an adjoining wheat field, and some were blown down by a wind storm in August, but the average yield of cane was very large.

The general plan of the analytical work was essentially the same as last year, which was fully described in Bulletin No. 20.

About 1,500 complete analyses were made from the different plots to determine the value of each as a whole. About 1,900 polarizations were made of single canes for the purpose of selecting seed from those of high sugar content. About 7,000 selections of seed heads were made by the saccharometer alone, of canes whose juice had unusual density. This station has sent in to the Department five tons of sorghum seed, consisting of average seed from the general lot of the different varieties, and 8,600 single seed heads. The latter are carefully preserved, each being tied up separately in a paper bag, and labelled with the name of the variety and number of the plot from which it was taken, and the analysis of its parent cane. Some of these pedigreed seed heads will be retained by the Department for its own use in case this work is con-

tinued under its supervision, and the rest will be distributed amongst the State experiment stations, sorghum sugar factories, and others interested in the improvement of the sorghum plant.

RESULTS OF ANALYSIS.

Owing to the limited space allowed for printing, it was found necessary to greatly curtail the quantity of analytical data to be published in this report. The following tables therefore represent only a small fraction of the work performed. Only one plot of each important variety is represented in the tables, and the plots of less promising and unnamed varieties are cut out, together with those of all except the most promising crosses and variations. All the analytical work has been tabulated, however, and will be preserved at the Department for reference, in order to be able to trace the history of either varieties, or individual cane seed selections. Only analyses of average samples taken from the entire plot are included in the following tables. These samples were taken in the same way as last year, except that a few analyses were made at the end of the season of samples taken as follows:

The near approach of cold weather and one or two heavy frosts having indicated that the season was at an end, such plots as were still in good condition were measured, and all the canes cut from the measured area. The sample of field cane obtained in this way was weighed, and from its weight the equivalent yield per acre was estimated; the cane was then topped and stripped and the whole passed through the large five-roller mill of the Sterling Sirup Works. The juice was retained in a common receptacle, and a sample taken for analysis. The object was to obtain a sample which would correctly represent a large quantity of cane, and also to see how the juice would compare with that of small average samples expressed by the hand-mill. The results show very little difference, and it is evident that the extraction by the large mill did not differ greatly from that obtained by the small mill.

They show also that our manner of sampling was accurate, and gave a good average representation of the entire plot.

FOLGER'S EARLY VARIETY.

[Planted May 4 with seed from a single selected stalk. This variety originated in a selection of a variation from Early Amber, made by A. S. Folger, of Iowa; the canes are larger than Amber, and mature nearly as early.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
205	Sept. 5	29	16.88	12.70	2.11
	Sept. 12	125	17.34	13.72	2.22
	Sept. 13	152	18.93	14.63	2.02
	Sept. 18	242	17.78	13.53	1.81
	Sept. 23	419	18.93	14.23	2.04
	Sept. 25	493	18.64	14.07	2.39
	Oct. 1	677	20.24	15.71	1.65

LINK'S HYBRID.

[Planted May 3 with seed from a single selected stalk. This variety appears to be one of the best, if not the best variety for sugar manufacture. More attention has been paid to it this year than to any other.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
154	Sept. 6	44	16 81	12.45	.99
	Sept. 20	321	17.47	13.37	.88
	Sept. 25	465	18.76	13.94	.69
	Sept. 30	624	19.34	15.15	.74
	Oct. 4	790	19.53	16.34	.55
	Oct. 12	1234	17.38	14.58	.60
	Oct. 22	1311	20.38	15.83	.26
	Oct. 26	1437	16.18	13.00	.53

PLANTERS' FRIEND.

[Planted May 4 with seed from a single selected stalk. A large number of plots was planted with this variety from single seed heads selected last year, but very few attained maturity. Many plots were blown down and tangled by the wind.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
186	Sept. 20	326	18.96	14.07	.93
	Sept. 23	412	18.96	13.52	1.92
	Sept. 25	485	18.66	14.06	1.70
	Sept. 28	574	18.81	13.71	1.80
	Oct. 2	701	19.94	14.75	1.67
	Oct. 7	895	18 70	14.26	1.86
	Oct. 19	1024	19.36	15.29	1.68
	Oct. 19	1269	17.59	14.18	1.11
	Oct. 23	1318	20.46	16.21	.55

HONDURAS.

[Planted May 6, from general lot of seed from last year.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
236	Oct. 7	916	15.60	11.70	1.71
	Oct. 11	1175	16.00	11.09	2.06
	Oct. 25	1404	15.72	13.22	1.89

HONDURAS (EARLY).

[Planted May 1 from a single early-maturing cane selected from Honduras. It is practically a new variety, or rather subvariety.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
119	Sept. 4	21	13.58	8.90	1.54
	Sept. 11	91	13.15	9.01	1.84
	Sept. 14	170	16.58	11.63	2.07
	Sept. 17	227	14.18	9.99	1.34
	Sept. 20	305	15.60	11.59	1.61
	Sept. 26	516	16.88	11.88	1.51
	Oct. 2	692	18.22	13.71	1.09
	Oct. 4	815	16.80	12.62	1.31
	Oct. 8	998	16.74	12.41	1.18

SORGHUM (BICOLOR).

[Planted April 22. The same variety as the unnamed plots Nos. 15, 47, and 52 last year. This variety was remarkable last year for its low glucose content, and this characteristic has remained constant throughout the various plots grown this year. It is possible that such a variety could be improved in its sucrose content without the loss of the good quality it already possesses of a low percentage of glucose.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
70	Oct. 4	822	18.95	13.42	.45
	Oct. 11	1185	19.61	14.45	.61
	Oct. 19	1275	17.69	12.85	.66
	Oct. 25	1387	17.81	13.48	.58

EARLY ORANGE (RIO BLANCO)

[Planted April 22 with seed obtained from Mexico; good canes, apparently the Early Orange, but the analyses are so superior to those of other plots that the name sent with the seeds, "Rio Blanco," is retained.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
107	Sept. 11	88	16.32	12.03	2.43
	Oct. 1	655	17.82	13.44	1.94
	Oct. 4	809	17.90	13.73	1.79
	Oct. 5	884	20.03	17.05	1.69
	Oct. 12	1241	18.80	14.84	1.42
	Oct. 25	1388	18.11	14.18	1.40

EARLY AMBER.

[Planted May 6 with seed from general lot of last year; later than usual in maturing and not quite so high in analysis as last year.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
235	Aug. 30	3	16.62	12.05	1.53
	Aug. 31	6	16.55	11.45	1.30
	Sept. 2	7	15.93	11.75	1.32
	Sept. 3	15	15.50	11.25	1.23
	Sept. 4	18	17.07	12.65	1.07
	Sept. 5	24	15.90	11.90	1.12
	Sept. 6	33	16.60	12.45	1.01
	Sept. 7	82	16.95	12.32	.93
	Sept. 13	132	15.93	11.85	.98
	Sept. 16	193	15.48	11.22	.84
	Sept. 19	283	15.72	11.89	1.00
	Sept. 23	384	16.42	11.81	.94

LATE ORANGE.

[Planted May 6 with general lot of last year's seed.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
241	Sept. 9	70	15.22	10.76	2.66
	Sept. 16	181	15.05	11.17	2.21
	Sept. 19	281	16.50	11.90	2.38
	Sept. 27	545	17.96	14.05	1.74
	Oct. 3	752	18.20	14.82	1.63
	Oct. 7	923	18.69	13.83	1.53
	Oct. 11	1173	20.80	15.71	1.92
	Oct. 25	1407	17.40	13.63	1.43

CHINESE IMPHEE.

[Planted April 22 with seed received from Dr. Collier. This plot was *not* Chinese in type, contained two distinct varieties, one of which may prove valuable.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
14	Sept. 14	163	15.75	11.37	.93
	Sept. 21	371	18.49	13.95	.41
	Sept. 24	442	18.70	14.60	.25
	Oct. 1	650	18.06	13.52	.83
	Oct. 8	949	18.60	15.19	.37
	Oct. 11	1184	18.90	14.24	.88

ANALYSES OF CROSSES AND VARIATIONS.

Following are the analyses of few of the plots planted from crosses or variations selected last year. While all such plots were analyzed to determine their value, no great amount of work was expended except in cases where the uniformity of the plot showed an established, or nearly established, type. There were quite a number of such plots, however, which showed not only an established type, but also an improvement in some directions over the variety or varieties from which it originated. Some showed remarkable qualities on analysis; as, for example, plots Nos. 291 and 293, which gave some of the highest individual cane analyses obtained this season. Many of these crosses seem to be sufficiently well established in type to justify their being designated as new varieties, but probably it will be safer to grow them one more year, at least, from selected heads, to guard against reversion. From our experience with these crosses it would appear that a variation or cross can become established in type within three years after its initial production; that is, from the time the seed germ is impregnated or modified.

All the following plots were planted from single selected seed heads:

AMBER AND ORANGE CROSS.

[Planted May 6. This and three similar plots were all planted from single seed heads selected from plot No. 153 last year. This cross will undoubtedly develop into a valuable new variety. It is a curious and encouraging fact, that the cane showing the highest content of sucrose last year should produce a plot this year (No. 293) from which the highest individual cane analysis of this season was obtained, giving the unprecedented result of 20.72 per cent. sucrose in the juice.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
253	Sept. 6	35	12.68	7.60	2.07
	Sept. 9	60	16.71	7.86	1.30
	Sept. 16	175	17.18	13.51	1.23
	Sept. 19	273	18.87	14.92	1.55
	Sept. 21	364	18.84	14.07	1.03
	Sept. 23	397	19.07	14.64	1.00
	Oct. 3	740	19.83	15.48	.84
	Oct. 7	907	18.38	16.94	.77
	Oct. 24	1361	18.98	15.21	.56

LINK'S HYBRID AND AMBER CROSS.

[Planted May 3. Canes uniform, good sized, not so tall as Link's Hybrid.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
172	Sept. 12	120	15.84	11.50	1.10
	Sept. 17	235	17.20	13.13	1.04
	Sept. 20	335	18.46	14.05	1.12
	Sept. 23	410	18.36	13.88	.90
	Sept. 25	469	17.85	14.26	.76
	Sept. 30	608	18.46	14.61	.74
	Oct. 2	702	19.00	14.87	.88
	Oct. 8	1006	20.55	15.69	.61
	Oct. 12	1224	18.30	14.72	.64
	Oct. 22	1312	19.42	14.80	.86

LINK'S HYBRID AND ORANGE CROSS.

[Planted May 3. Large canes, not uniform, revert to both parent types.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
159	Sept. 20	322	15.64	11.85	1.76
	Sept. 25	488	17.11	13.13	1.18
	Sept. 25	489	17.26	13.27	1.30
	Sept. 25	490	15.57	10.18	2.41
	Sept. 30	622	17.34	12.70	1.98
	Oct. 4	799	18.60	13.69	1.85
	Oct. 9	1043	18.40	14.61	.95
	Oct. 12	1217	18.34	14.43	.78
	Oct. 22	1295	18.20	13.58	1.12

LINK'S HYBRID AND RED LIBERIAN CROSS.

[Planted May 3. Uniform in type, strong and stocky canes.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
176	Sept. 12	118	14.18	9.18	2.70
	Sept. 20	343	19.56	13.47	1.02
	Sept. 23	421	19.36	11.60	.85
	Oct. 10	1136	20.09	14.71	1.26
	Oct. 22	1300	20.40	14.92	.55

VARIATION OF LINK'S HYBRID.

[Planted May 3. Short, stocky canes, very uniform in type, seem to be free from faults of Link's Hybrid. A decidedly good variation.]

[In the juice.]

Plot.	Date.	No. of analysis.	Total solids, Brix.	Sucrose.	Glucose.
			Per cent.	*Per cent.*	*Per cent.*
171	Sept. 12	122	16.14	12.22	.94
	Sept. 20	336	18.76	14.57	.84
	Sept. 25	474	17.85	13.61	.71
	Oct. 8	1007	18.40	16.35	.62
	Oct. 12	1237	18.00	14.39	.59
	Oct. 22	1289	19.60	15.18	.46

SUMMARY OF THE ANALYSES.

In the following table will be found the maximum analysis attained by each plot, as shown by average samples taken from the entire plot. This table includes all the plots of distinct varieties which were examined.

Maximum analysis of each variety in 1889.

[Analyses of average samples of entire plot.]

[In the juice.]

Variety.	Plot.	Date.	No. of Analyses.	Total solids, Brix.	Sucrose.	Glucose.	Coeff. of purity.
				Per cent.	*Per cent.*	*Per cent.*	
Early Amber	01	Oct. 4	810	15.38	12.67	1.28	82.38
	049	Oct. 8	955	17.18	12.65	1.26	73.63
	050	Oct. 4	804	15.78	11.99	1.04	75.98
	235	Sept. 6	33	16.60	12.45	1.01	75.00
Folger's Early Variety	247	Sept. 30	594	15.24	12.74	1.53	83.59
	205	Oct. 1	677	20.24	15.71	1.65	77.61
Whiting's Early Variety	379	Sept. 5	32	16.66	11.75	1.31	70.53
Early Tennessee	245	Sept. 6	34	10.98	8.65	3.35	78.77
Link's Hybrid	244	Oct. 7	921	19.28	16.12	.63	83.61
	10	Oct. 23	1316	17.49	14.06	.24	80.39
	116	Oct. 8	972	19.59	16.14	.61	82.39
	149	Oct. 22	1287	18.07	15.29	.50	84.61
	150	Sept. 30	605	19.27	15.76	.62	81.78
	153	Oct. 8	1001	20.94	16.05	.47	76.64
	154	Oct. 4	790	19.53	16.34	.55	83.66
	155	Oct. 22	1296	17.36	12.78	2.02	73.62
	162	Oct. 22	1294	19.98	15.68	.37	78.47
	163	Oct. 22	1303	20.58	15.83	.48	76.91
	164	Oct. 9	1031	21.34	16.52	.68	77.41
	165	Sept. 25	479	19.98	15.90	.64	79.57
	166	Oct. 22	1307	20.02	15.58	.54	77.82
Planters' Friend	177	Oct. 9	1025	16.76	11.22	2.24	66.95
	180	Oct. 7	962	14.20	10.05	1.92	70.77
	181	Oct. 24	1350	14.34	8.95	2.10	62.41
	182	Oct. 24	1358	16.44	11.37	1.75	69.16
	184	Oct. 24	1353	15.24	10.29	2.11	67.52
	185	Oct. 5	705	16.88	11.06	3.34	65.52
	186	Oct. 23	1318	20.46	16.21	.55	79.20
	188	Oct. 24	1352	16.54	10.92	1.95	66.02
	189	Oct. 24	1351	17.94	13.09	1.09	72.96
	190	Oct. 24	1359	15.94	10.76	1.93	67.50
	191	Oct. 24	1348	16.78	12.17	1.54	72.47
	376	Oct. 26	1427	20.00	14.00	2.36	70.00
Honduras	236	Oct. 25	1404	15.72	13.22	1.89	84.10
	3	Oct. 25	1380	17.07	12.93	.81	75.90
Honduras (Rose de Senegal)	103	Oct. 25	1397	16.52	12.80	1.02	77.50
Honduras	105	Oct. 12	1214	17.54	12.77	1.69	72.80
	383	Oct. 25	1413	14.38	8.06	2.91	56.05
Honduras (Texas Red)	108	Oct. 8	975	16.74	12.67	1.13	75.85
Honduras	115	Oct. 12	1225	15.42	9.85	2.64	63.90
Honduras (Early)	119	Oct. 2	692	18.22	13.71	1.09	75.26
	120	Sept. 26	517	17.78	13.01	2.40	73.17
Red Liberian	27	Oct. 11	1192	20.00	14.90	1.82	74.50
	243	Oct. 7	933	17.91	10.83	3.97	60.47
	385	Oct. 14	1260	17.57	13.32	2.84	75.81
	124	Oct. 5	859	17.62	12.14	4.14	68.89
	125	Oct. 5	872	18.85	14.89	2.81	79.04
	126	Oct. 5	869	18.75	13.25	2.85	70.67
	127	Oct. 5	866	18.79	13.97	2.73	74.35
	128	Oct. 23	1328	18.34	13.83	2.18	75.41
	129	Oct. 23	1324	18.54	13.06	2.26	70.44
	130	Oct. 23	1329	17.34	12.48	2.48	71.97
	133	Oct. 23	1320	17.30	12.68	2.36	73.29
	134	Oct. 23	1337	17.84	13.28	2.78	74.44
	135	Oct. 23	1330	18.14	12.60	7.86	69.46
	136	Oct. 10	1335	17.54	12.63	1.86	72.01
	138	Oct. 23	1327	17.54	12.14	2.86	69.21
	139	Oct. 5	878	18.75	13.25	3.12	70.67
	140	Oct. 10	1324	18.89	12.43	.....	65.80
	141	Oct. 10	1116	18.78	13.69	3.40	72.89
	142	Oct. 23	1323	16.84	11.49	2.59	68.23
	145	Oct. 24	1342	15.74	10.79	3.08	68.42

Maximum analysis of each variety in 1889—Continued.

Variety.	Plot.	Date.	No. of Analyses.	Total solids, Brix.	Sucrose.	Gluscose.	Coeff. of purity.
				Per cent.	*Per cent.*	*Per cent.*	
Red Liberian	374	Oct. 26	1432	22.34	14.67	2.94	65.67
	375	Oct. 26	1440	16.80	10.86	3.59	64.64
	144	Oct. 23	1331	18.14	13.62	1.78	75.08
Sorghum (Bi-color)	51	Oct. 11	1178	19.60	14.11	.76	71.99
	70	Oct. 11	1185	19.61	14.45	.61	73.69
	74	Oct. 1	653	17.30	13.47	1.01	77.86
	231	Oct. 11	1172	19.20	13.42	.76	69.89
	258	Oct. 7	903	16.20	13.77	.64	85.00
	259	Oct. 7	920	19.29	13.56	.81	70.29
	394	Oct. 5	837	18.60	13.78	.74	74.09
	395	Oct. 26	1452	15.90	10.60	1.27	66.67
	396	Oct. 26	1448	18.10	12.70	1.15	70.16
	261	Oct. 3	739	17.07	12.11	1.03	70.94
Kansas Orange	1	Oct. 8	959	19.40	15.39	.61	79.33
	2	Oct. 11	1197	18.49	14.98	.56	80.95
	15	Sept. 24	443	16.80	13.20	1.19	78 60
	240	Sept. 9	73	15.28	11.40	1.52	75.60
	390	Oct. 26	1443	17.64	13.70	.74	77.66
	200	Oct. 1	679	19.76	14.57	1.70	78.79
Early Orange	242	Oct. 3	750	16.50	12.34	2.23	74.78
	239	Oct. 7	918	19.40	14.65	2.20	75.52
	382	Oct. 5	835	20.04	14.42	2.14	71.95
	207	Sept. 23	423	18.16	14.76	3.21	81.27
Early Orange (Rio Blanco)	107	Oct. 5	884	20.03	17.05	1.69	85.12
New Orange (Neeazana)	193	Oct. 9	1085	19.89	14.21	2.84	71.44
	216	Oct. 7	927	19.59	14.22	2.03	72.59
	238	Oct. 3	745	19.20	14.91	1.75	77.65
	12	Oct. 8	958	20.20	14.85	1.65	73.51
Late Orange	241	Oct 11	1173	20.80	15.71	1.92	75.53
	386	Oct. 5	832	18.21	14.76	2.18	81.06
Improved Orange	370	Oct, 3	770	20.06	14.20	3.08	70.78
	371	Oct. 5	842	16.40	12.79	2.18	77.98
	213	Sept. 30	631	19.51	14.94	2.34	76.57
	204	Oct. 26	1468	18.84	13.76	2.23	73.03
Chinese	39	Oct. 4	819	17.40	13.41	1.13	77.06
	58	Oct. 1	650	16.22	13.48	1.69	83.11
	76	Oct. 8	990	14.54	12.00	1.33	82.53
	79	Oct. 8	981	17.14	13.33	1.49	77.77
Chinese (Pootung)	80	Oct. 12	1213	16.44	13.47	1.06	81.94
Chinese	81	Oct. 8	986	17.50	13.45	1.03	76.86
	223	Oct. 3	761	15.20	10.99	2.48	72.30
	229	Oct. 27	555	16.57	11.01	1.91	66.45
Chinese (Shaw's variety)	260	Sept. 23	393	15.80	12.58	2.58	79.62
Chinese (Jyangentombi)	35	Oct. 1	651	18.20	14.63	.93	80.39
Chinese (Black Sorghum)	9	Oct. 8	957	18.20	13.32	1.55	73.19
Chinese	199	Sept. 23	420	17.54	12.22	2.75	69.67
Undendebule	254	Oct. 7	919	20.89	16.39	.81	78.46
	31	Oct. 1	662	21.22	16.77	.54	79.03
	397	Oct. 12	1210	19.14	17.12	.72	89.45
	392	Oct. 11	1164	18.60	14.07	1.42	22.28
White India	28	Oct. 19	1276	14.18	11.62	1.49	81.94
White India (White Mammoth)	401	Oct. 20	1398	16 00	10.95	2.11	68.44
Ubehlana	34	Oct. 8	993	19.34	14.07	1.97	72.75
	226	Oct. 3	758	16.80	12.33	2.92	73.39
	378	Oct. 10	1,114	19.68	13.49	2.64	68.54
	400	Oct. 19	1,273	15.76	11.46	.....	72.62
Texas Honey Drip	368	Oct. 26	1,423	21.30	16.35	2.42	76.76
Price's New Hybrid	251	Sept. 19	279	15.30	10.05	2.05	65.68
White African	237	Sept. 23	399	19.29	13.71	1.09	71.07
Black African	109	Oct. 5	877	19.75	15.46	.51	78.28
White Enfield	230	Oct. 24	1,355	17.10	12.51	.53	73.16
Ufatane	18	Oct. 4	823	19.15	14.38	.47	75.09
Uboyana	36	Oct. 11	1,196	17.18	12.17	1.62	70.84
Dendenmka	37	Oct. 4	821	17.42	12.67	.80	73.31
Sorghum (Bleu)	101	Oct. 12	1,211	17.84	12.42	1.18	69.62
Large Goose-neck	192	Oct. 7	900	10.60	2.34	4.92	22.08
Ukubane	32	Sept. 28	578	18.66	13.89	.53	74.43
Ungatubanda	21	Oct. 1	646	15 93	12.17	.81	76.39
Chinese Imphee	14	Oct. 8	949	18.60	15.19	.37	81.67
Iowa Red Top	16	Oct. 4	820	19.97	14.67	.70	73.46

UNNAMED VARIETIES.

[Analyses of average sample of entire plot.]

[In the juice.]

Plot.	Date.	No. of anaylses.	Total solids, Brix.	Sucrose	Glucose	Co-efficient of purity.
			Per cent.	*Per cent.*	*Per cent.*	
23	Oct. 11	1,183	18.80	13.40	1.90	71.28
257	Sept. 27	553	17.37	12.60	.81	72.54
30	Oct. 26	1,454	12.70	5.94	1.79	46.77
225	Oct. 3	753	13.60	8.64	2.08	63.53
404	Oct. 26	1,455	15.60	9.30	1.71	59.62
389	Oct. 11	1,156	17.54	11.27	2.96	64.25
227	Oct. 11	1,174	18.20	11.92	2.65	65.49
221	Oct. 7	924	17.28	12.94	1.24	74.88
224	Oct. 7	929	16.08	10.66	2.40	66.29
228	Oct. 7	936	19.81	14.06	1.90	70.97
380	Oct. 10	1,144	18.69	11.61	3.26	62.12
391	Oct. 11	1,157	16.64	10.90	1.52	65.51
248	Oct. 11	1,165	16.90	11.93	1.10	70.59
373	Oct. 26	1,434	20.56	14.37	2.70	69.89
218	Oct. 1	647	16.23	11.57	.94	71.29
234	Oct. 7	932	18.61	14.14	1.33	70.61
250	Oct. 24	1,364	17.80	14.33	.74	80.51
393	Oct. 11	1,159	19.14	14.86	1.01	77.64

From the above table the following list has been taken of ten varieties giving the best results in the three essential points of high sucrose, low glucose, and high purity.[1]

List of ten varieties giving best results in 1889.

[In the juice.]

No.	Varieties.	Sucrose.	No.	Varieties.	Glucose.	No.	Varieties.	Co-efficient of purity.
		Per ct.			*Per ct.*			
1	Undendebule	17.12	1	Link's Hybrid	.24	1	Undendebule	89.45
2	Early Orange	17.05	2	Chinese Imphee	.37	2	Early Orange	85.12
3	Link's Hybrid	16.52	3	Ufatane	.47	3	Sorghum (Bicolor)	85.00
4	Texas Honey Drip	16.35	4	Black African	.51	4	Link's Hybrid	84.61
5	Planter's Friend	16.21	5	Ukubane	.53	5	Honduras	84.10
6	Folger's Early Variety.	15.71	6	White Enfield	.53	6	Folger's Early Variety.	83.59
7	Late Orange	15.71	7	Undendebule	.54	7	Chinese	83.11
8	Black African	15.46	8	Planter's Friend	.55	8	Early Amber	82.38
9	Kansas Orange	15.39	9	Kansas Orange	.56	9	White India	81.94
10	Chinese Imphee	15.19	10	Sorghum (Bicolor)	.61	10	Chinese Imphee	81.67

From a comparison of the records made by the different varieties this year and last, the following points will be noticed:

(1) The ten varieties giving the best results in sucrose content in 1889 ranged from 17 to 15 per cent., all being above the latter figure; in 1888 the range was from 15 (circa) to 13 per cent., a difference of just about 2 per cent. between the two seasons.

(2) The ten varieties giving the lowest contents of glucose in 1889, from .25 to .60 per cent; in 1888 the range was from .50 to 1 per cent., a difference of about .40 per cent.

[1] Bull. 20, p. 126.

(3) The ten varieties giving the highest purities in 1888 ranged from 76 to 72; in 1889 from 89 to 82, a difference of over 10 points.

The superior quality of the canes this year as compared with last is principally due, as already explained, to the fact that the growing season was much better this year.

(4) The two tables giving the list of ten varieties showing best results comprise eighteen varieties each; of these, nine varieties are found in both tables, that is to say, made a good showing in at least one essential for both years. Following is the list:

List of nine varieties giving good results in at least one essential for two years.

Undendebule.	Kansas Orange.	Early Amber.
Link's Hybrid.	Sorghum Bicolor.	White Indian.
Early Orange.	Chinese.	Planter's Friend.

Of the remaining twenty-seven varieties which made a showing in but one year only, some were new this year, and some were handicapped by the late season.

(5) Link's Hybrid would seem to be entitled to the first place as an "all-around" good variety, having made a remarkable record in all three essentials for two years. Undendebule comes next, having made a record last year for low glucose and high purity, and this year obtaining a record for low glucose and heading the list in the other essentials. Red Liberian and Plot No. 14, which made such a good showing last year, do not appear amongst the first ten this year at all, although the sucrose content of both was greater this year than last; the late season was unfavorable to them.

The following table gives the maximum seed selection from each plot; it will be seen that as a rule the plot which gave the highest average analysis of its variety, gives also the highest individual cane analysis:

Maximum analysis of selected canes from each variety.

[Analyses of single stalk seed selections.]

[In the juice.]

Variety.	Plot.	Date.	No. of analyses.	Total solids, Brix.	Sucrose.	Glucose.	Co-efficient of Purity.
				Per cent.	*Per cent.*	*Per cent.*	
Early Amber	235	Sept. 7	1,140	18.87	14.95	.96	79.22
Folger's Early Variety	205	Sept. 28	11,567	20.47	16.48	.70	80.50
Link's Hybrid	244	Oct. 19	13,526	21.35	16.72	.....	78.31
	11	Oct. 10	13,161	21.83	17.24	.....	78.97
	116	Oct. 8	12,815	23.24	18.89	.....	81.28
	149	Oct. 4	12,816	21.80	17.12	.....	78.53
	150	Oct. 3	12,050	22.21	17.94	.....	80.77
	153	Oct. 8	12,858	23.43	17.95	.39	76.61
	154	Oct. 8	12,715	23.23	18.53	.47	79.76
	162	Oct. 1	11,834	23.49	17.76	.....	75.60
	163	Sept. 27	11,517	22.35	17.43	.57	77.98
	164	Oct. 1	11,852	23.34	17.91	.....	76.73
	165	Sept. 27	11,495	21.89	17.60	.44	80.40
	166	Oct. 2	11,927	23.50	18.51	.95	78.76
Planter's Friend	186	Oct. 19	13,578	22.52	16.75	.....	74.37

Maximum analysis of selected canes from each variety—Continued.

Variety.	Plot.	Date.	No. of analyses.	Total solids, Brix.	Sucrose.	Glucose.	Co-efficient of Purity.
				Per cent.	*Per cent.*	*Per cent.*	
Red Liberian	125	Oct. 11	13,259	21.56	15.61	.....	72.40
	126	Oct. 11	13,247	21.03	15.35	.....	72.99
	127	Oct. 11	13,298	21.91	15.61	.....	71.24
	128	Oct. 11	13,301	21.96	16.20	.....	73.77
	129	Sept. 21	13,623	19.63	14.72	.....	74.98
	130	Oct. 21	13,645	20.60	14.90	.....	72.33
	134	Oct. 21	13,632	19.76	13.76	.....	69.63
	135	Oct. 21	13,629	20.63	14.04	.....	67.05
	138	Oct. 21	13,655	20.40	13.97	.....	68.48
	139	Oct. 21	13,683	20.33	14.07	.....	69.20
	140	Oct. 21	13,698	20.63	13.99	.....	67.81
	141	Oct. 22	13,721	21 18	14.96	.....	70.63
	142	Oct. 21	13,689	20.33	14.02	.....	68.96
Sorghum (bi-color)	51	Oct. 4	12,299	21.71	15.44	.....	71.11
	70	Oct. 4	12,304	20.36	15.11	.....	74.36
	231	Oct. 5	12,334	20.18	14.85	.59	73.58
	258	Oct. 4	12,281	20.61	14.69	.....	71.27
	259	Oct. 4	12,279	21.44	15.59	.52	72.71
	394	Oct. 12	13,429	19.62	15.03	.....	76.60
	396	Oct. 23	13,873	19.48	14.93	.....	76.83
	261	Oct. 5	12,395	22.90	16.52	.....	72.13
Kansas Orange	200	Oct. 2	11,893	21.49	16.50	1.31	76.77
Early Orange	239	Oct. 7	12,512	23.63	17.43	.....	73.76
Early Orange (Rio-Blanco)	107	Oct. 7	12,550	22.90	17.75	1.41	77.51
New Orange (Neeazana)	193	Sept. 27	11,456	20.62	17.07	.....	82.77
	216	Oct. 10	13,167	21.83	15.80	.....	72.37
	12	Sept. 26	11,442	22.09	16.51	2.21	74.73
Late Orange	241	Oct. 5	12,451	21.83	17.34	.....	79.43
Improved Orange	370	Oct. 12	13,373	22.54	15.80	.....	70.09
	213	Sept. 28	11,577	20.55	16.18	.....	78.73
Chinese	39	Oct. 24	13,947	19.15	14.00	.....	73.10
Chinese (Jyangenbombi)	35	Oct. 25	13,957	19.98	14.71	.....	73.62
Undendebule	254	Oct. 2	11,971	24.39	19.81	.71	81.22
	31	Oct. 2	12,007	25.07	19.58	.....	78.10
	397	Oct. 14	13,460	20.16	16.16	.....	80.15
	392	Oct. 23	13,778	18.71	13.96	.....	74.61
Ubehlana	34	Oct. 25	13,961	19.98	14.81	.....	74.12
	226	Oct. 26	14,150	18.42	12.96	.....	70.35
White African	237	Sept. 26	11,448	19.76	13.73	.....	69.49
Black African	109	Sept. 20	11,237	21.90	16.70	.67	76.25
Ufatane	18	Oct. 12	13,379	21.30	16.07	.....	75.44
Chinese Imphee	14	Sept. 25	11,369	22.41	17.15	.43	76.52
Iowa Red-top	16	Sept. 26	11,434	20.29	15.86	.64	78.16

Maximum analysis of unnamed varieties.

[Analyses of single stalk seed selections.]

UNNAMED VARIETIES.

[In the juice.]

Plot.	Date.	No. of analyses.	Total solids, Brix.	Sucrose.	Glucose.	Co-efficient of Purity.
			Per cent.	*Per cent.*	*Per cent.*	
228	Oct. 26	14,154	19.32	16.09	.....	83.28
373	Oct. 12	13,348	23.71	18.03	1.42	76.04
218	Oct. 7	12,516	20.43	13.60	.77	66.56
250	Oct. 7	12,611	22.69	16.99	.91	74.87
393	Oct. 23	13,779	19.02	15.98	.....	84.01

From the above table the following list has been prepared, giving the ten varieties showing the highest results in sucrose from analyses of single selected stalks. It will be seen that nearly the same varieties are comprised in it as those contained in the table giving the ten best varieties of sucrose content from analyses of average samples, and the order is also about the same.

List of ten varieties giving best results based on analyses of single selected stalks (1889).

[In the juice.]

Variety.	Sucrose.	Variety.	Sucrose.
	Per cent.		*Per cent.*
1. Undendebule	19.81	6. Chinese Imphee	17.15
2. Link's Hybrid	18.89	7. New Orange	17.07
3. Plot 373	18.03	8. Plot 250	16.99
4. Early Orange	17.75	9. Planter's Friend	16.75
5. Late Orange	17.34	10. Black African	16.70

Following is a list of the five plots of crosses giving the highest sucrose content for the season:

[In the juice.]

Plot.	Variety.	Sucrose.
		Per cent.
293	Amber and Orange Cross	16.94
318	White India and Orange Cross	16.70
111	Variation of Honduras	16.51
171	Variation of Link's Hybrid	16.35
313		15.85

GENERAL CONCLUSIONS.

In summing up the results of two seasons of experimental work in improving sorghum, it may be said that where crossing of varieties and subvarieties has been excluded, it appears to inherit the qualities and even the peculiarities of the parent as closely as other plants.

Some of the new varieties have shown a high percentage of sugar for two seasons.

Some of the new varieties tested have shown for two seasons a much lower percentage of uncrystallizable sugar than the ordinary varieties.

Some of the varieties have retained a high percentage of sugar for from thirty to forty-eight days.

It appears that much of the extreme variableness which has been attributed to the sorghum plant is caused by differences in time of maturing in the canes, and it appears that these differences may be diminished by "family breeding," that is, separate planting of selected seed, and also by such methods of planting and of cultivation as will cause all the canes to mature before any deteriorate.

It appears that valuable new varieties may be produced by crossing two good varieties, and that new varieties having distinct and uniform characters can be produced by selecting variations from ordinary types.

It appears that early maturing subvarieties may be produced from varieties which mature too late by selecting seed from the first maturing canes of those varieties.

While the results obtained by a first selection in one season can not not be regarded as conclusive, yet it appears that improved varieties of sorghum which will yield more sugar than the best of the present varieties may be created by continued selection of seed from the canes which yield most sugar.

INDEX.